BIGGS CARDOSA
ASSOCIATES INC
STRUCTURAL ENGINEERS

1871 The Alameda, Suite 200
San Jose, CA 95126-1752
Telephone 408-296-5515
Facsimile 408-296-8114

Santa Clara Valley Water District

PERMANENTE CREEK PLANNING STUDY

Located in Santa Clara County, CA

STRUCTURAL INTEGRITY STUDY

Supplement 6

Materials Testing Reports

TC 425 P47 S76 2000 suppl c.1

BIGGS CARDOSA ASSOCIATES INC
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871 The Alameda, Suite 200
San Jose, California 95126
Telephone 408-296-5515
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FAXED
7-21-00

FACSIMILE TRANSMITTAL

DATE: July 21, 2000 **TIME:** 9:20 AM
FROM: Ronald L. Oen **JOB NO.:** 99027 FN395.03

PLEASE DELIVER THE FOLLOWING PAGES TO:

NAME: Meg Stemper

COMPANY: Meg Stemper Technical Communications

FAX #: (413) 397-9795

NUMBER OF PAGES INCLUDING COVER SHEET: 21

SUBJECT: Permanente Creek Structural Integrity Study Project

REMARKS:

Hi Meg,

If I recall correctly one of the SCVWD comments was to include the back-up geologic information in the appendix. This would include the Log of Test Borings, Geologic Map, Fault Map, and Laboratory Test Results of the soil. I just received them from our Geotechnical subconsultant.

I do not have them electronically but the following is a fax of them for your reference. Please create a placeholder for them in the report appendix and include them in the Table of Contents.

Thanks

Please do not hesitate to call if you have any questions.

IF YOU DO NOT RECEIVE ALL OF THE PAGES, PLEASE NOTIFY US AS SOON AS POSSIBLE AT PHONE (408) 296-5515 OR FAX (408) 296-8114.

Parikh Consultants, Inc.
481 Valley Way, Bldg. 1
Milpitas, CA 95035
Geotechnical Engineering

el: (408) 945-1011 Fax: (408) 945-1012

Letter of Transmittal

DATE 7/14/00 JOB NO. 99106.10
ATTENTION MR. RON OEN
RE: HALE PERMANENTE CREEK PROJECT

BIGGS CARDOSA ASSOC.
1871 THE ALAMEDA, #200
SAN JOSE, CA 95126

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via ______ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications
☐ Copy of letter ☐ Change order ☐ ______

COPIES	DATE	NO.	DESCRIPTION
1			GEOLOGIC MAP (PLATE 3), FAULT MAP (PLATE 4)
1			LOG OF BORINGS (PLATES A-1A - A-11)
1			LABORATORY TESTS (PLATES B-1 - B-4)

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submited ☐ Resubmit ____ copies for approval
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REMARKS ______

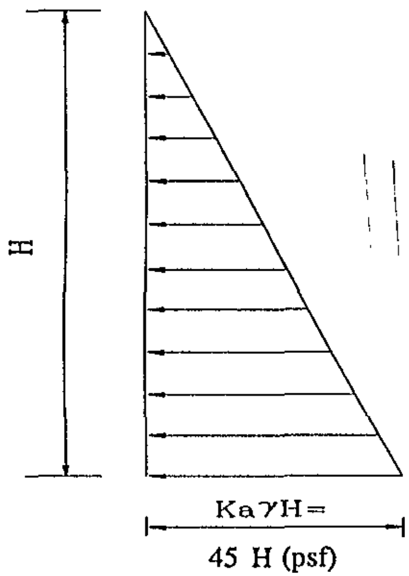
COPY TO ______ SIGNED: ______

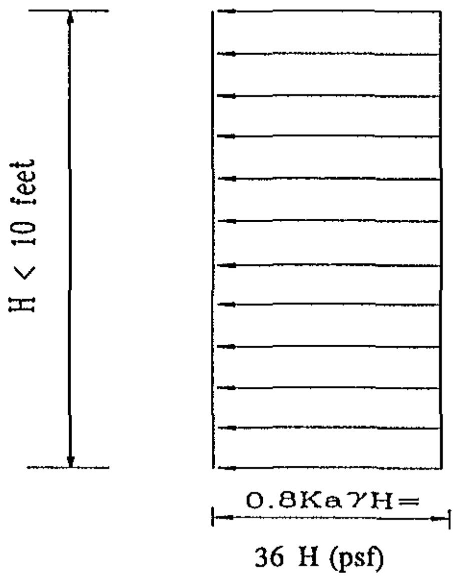
If enclosures are not as noted, kindly notify us at once

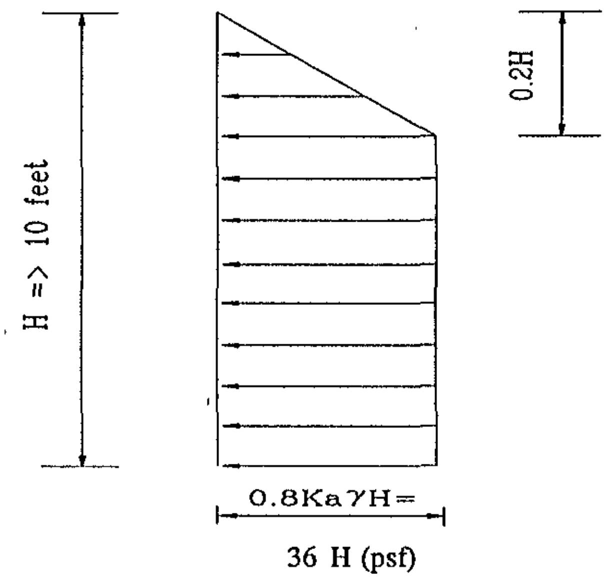
LATERAL EARTH PRESSURE DISTRIBUTION:

HALE & PERMANENTE CREEK CHANNELS
0

Date: 10/21/99
Job No.: 99106.1







For Cantilever Walls
(U-CHANNEL)

Wall Height < 10'

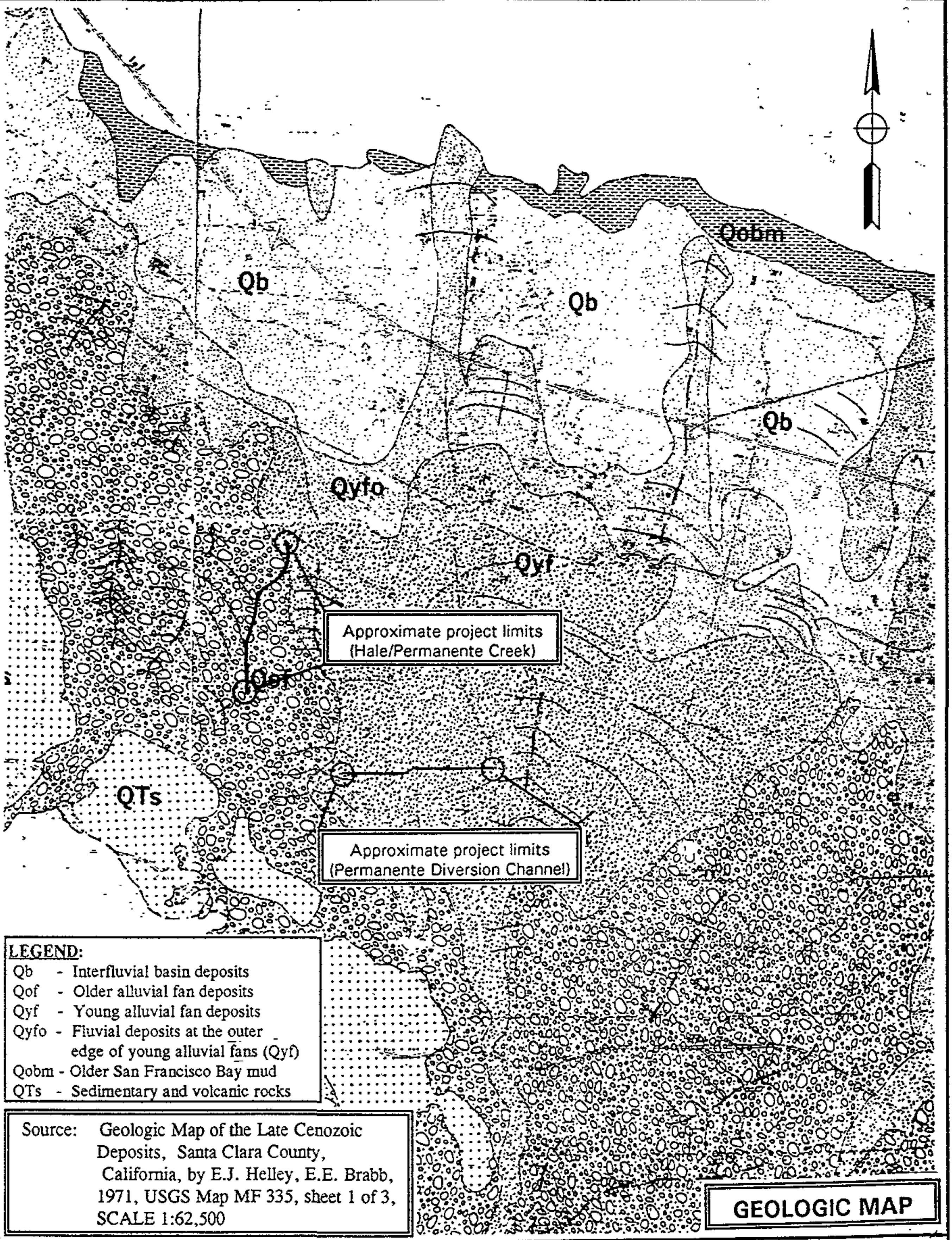
Wall Height => 10'

Flexible Trapezoidal Channel, restrained at the top

Notes:

1) Ka obtained by trial wedge analysis using Coulombs theory
2) γ = effective unit weight of the retained material
3) Lateral pressures due to live load, adjacent structures or ground water should be added to earth pressures indicated above

Reference: Caltrans "Memo To Designers: 5-12", August 1990


Qobm
Qb
Qb
Qb
Qyfo
Qyf
Qof
QTs
Approximate project limits
(Hale/Permanente Creek)
Approximate project limits
(Permanente Diversion Channel)

LEGEND:
Qb - Interfluvial basin deposits
Qof - Older alluvial fan deposits
Qyf - Young alluvial fan deposits
Qyfo - Fluvial deposits at the outer edge of young alluvial fans (Qyf)
Qobm - Older San Francisco Bay mud
QTs - Sedimentary and volcanic rocks

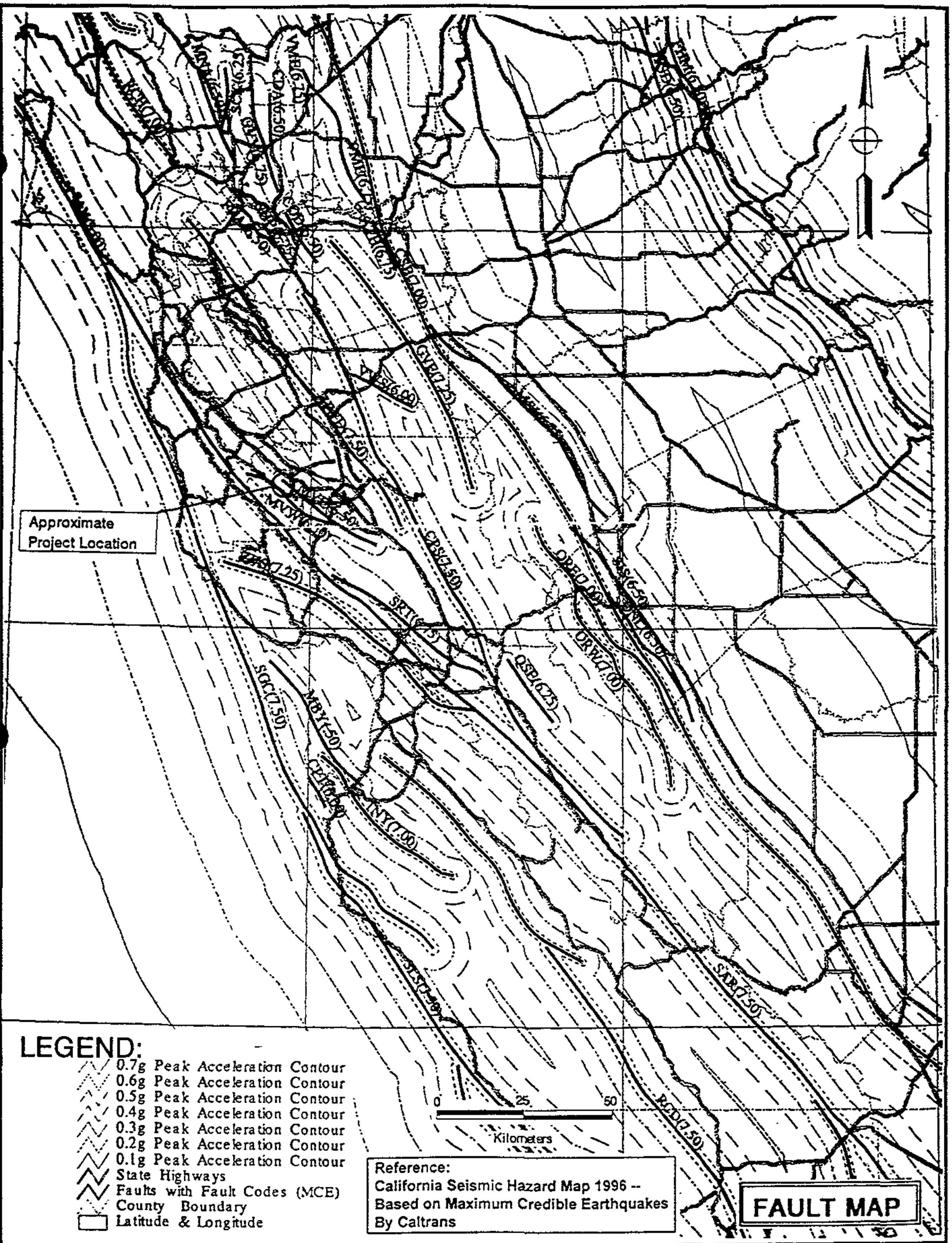
Source: Geologic Map of the Late Cenozoic Deposits, Santa Clara County, California, by E.J. Helley, E.E. Brabb, 1971, USGS Map MF 335, sheet 1 of 3, SCALE 1:62,500

GEOLOGIC MAP

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10
PLATE NO: 3



LEGEND:
- 0.7g Peak Acceleration Contour
- 0.6g Peak Acceleration Contour
- 0.5g Peak Acceleration Contour
- 0.4g Peak Acceleration Contour
- 0.3g Peak Acceleration Contour
- 0.2g Peak Acceleration Contour
- 0.1g Peak Acceleration Contour
- State Highways
- Faults with Fault Codes (MCE)
- County Boundary
- Latitude & Longitude

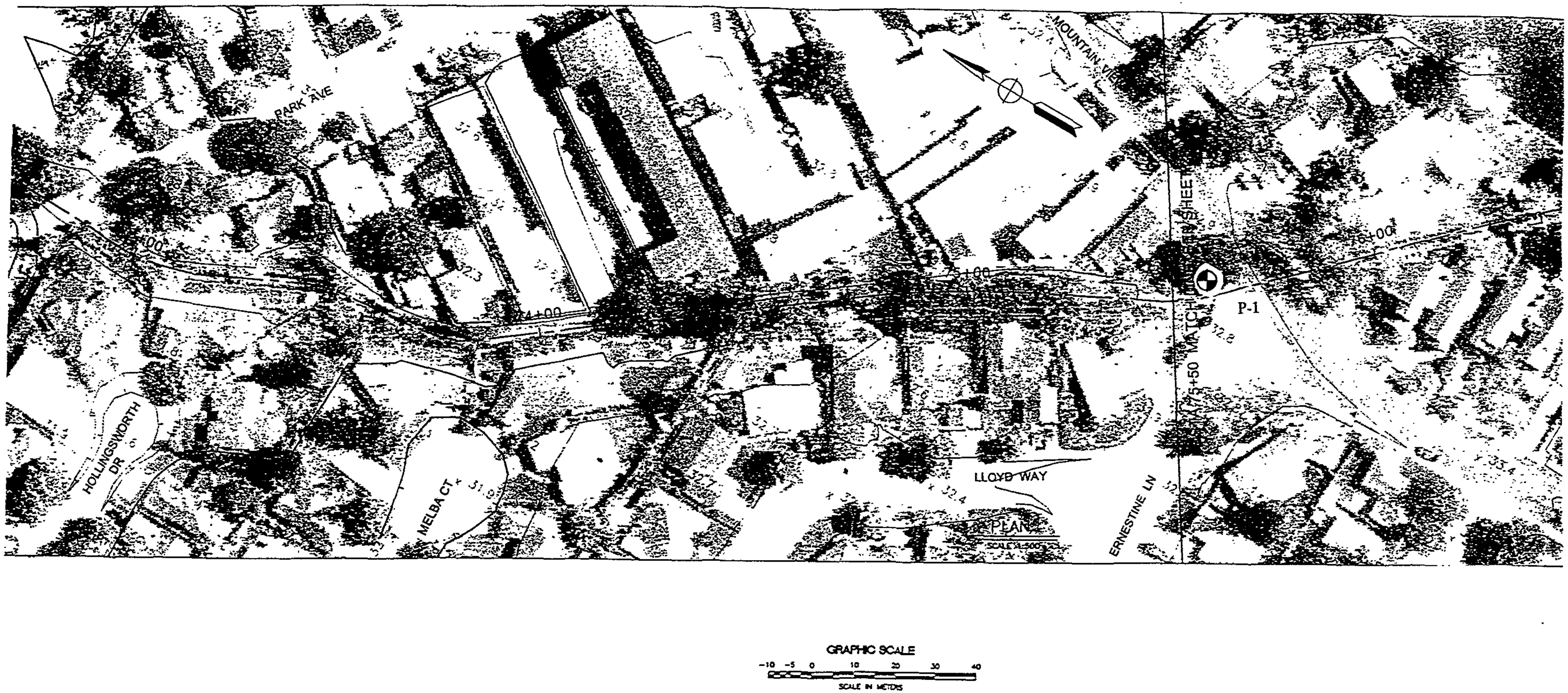
Reference:
California Seismic Hazard Map 1996 --
Based on Maximum Credible Earthquakes
By Caltrans

FAULT MAP

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10	PLATE NO: 4



SCALE: 1:1,000

SITE PLAN

SOURCE: Santa Clara Valley Water District, Map and General Plan for Permanente Creek and Hale Creek, San Francisco Bay to Foothill Expressway, Dated 3/12/99

LEGEND:

⊕ Approx. Boring Location

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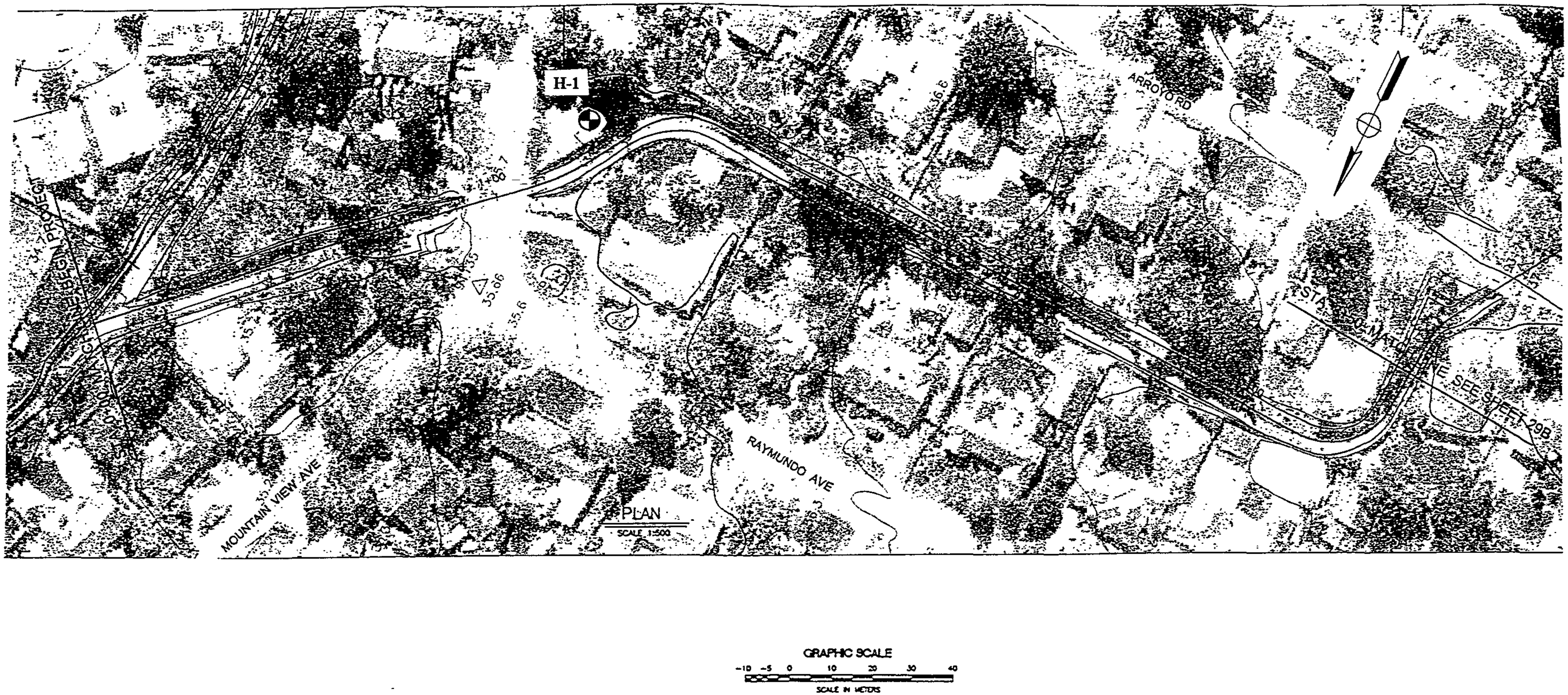
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10

PLATE NO.: 2A



SCALE: 1:1,000

SITE PLAN

SOURCE: Santa Clara Valley Water District, Map and General Plan for Permanente Creek and Hale Creek, San Francisco Bay to Foothill Expressway, Dated 3/12/99

LEGEND:

⊕ Approx. Boring Location

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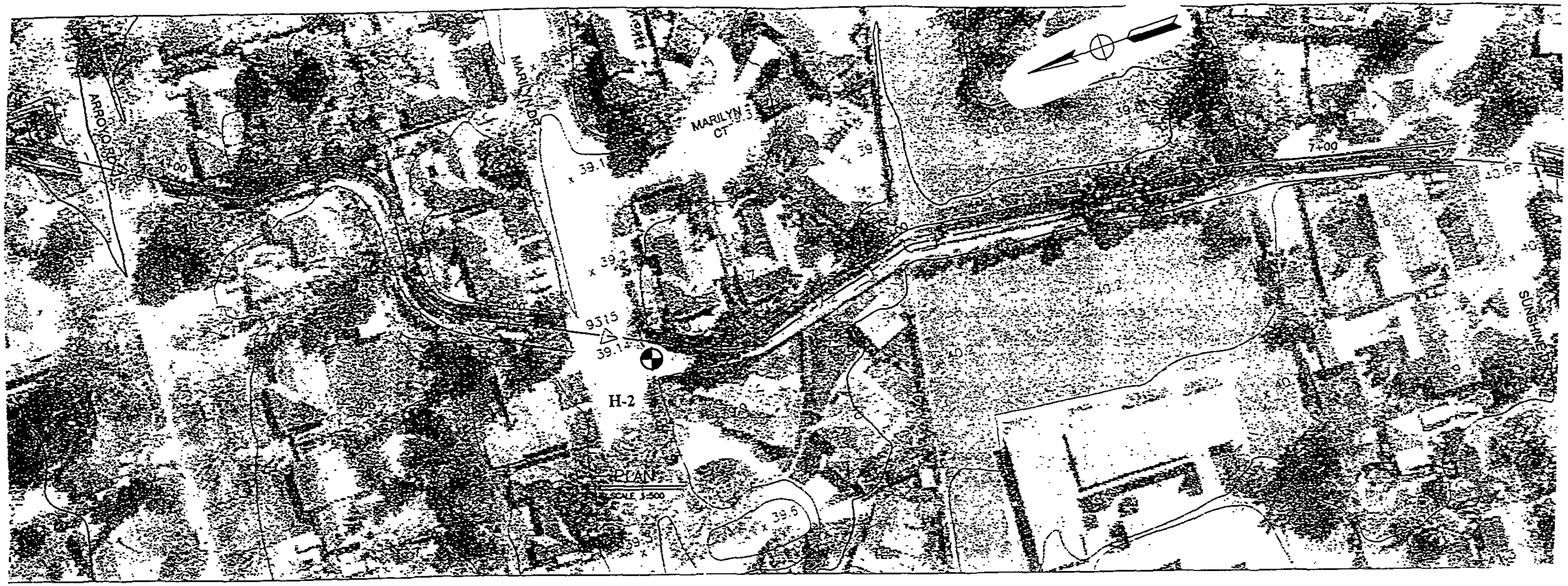
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10	PLATE NO.: 2B



GRAPHIC SCALE
-10 -5 0 10 20 30 40
SCALE IN METERS

SCALE: 1:1,000

SITE PLAN

SOURCE: Santa Clara Valley Water District, Map and General Plan for Permanente Creek and Hale Creek, San Francisco Bay to Foothill Expressway, Dated 3/12/99

LEGEND:

● Approx. Boring Location

PARIKH CONSULTANTS, INC.
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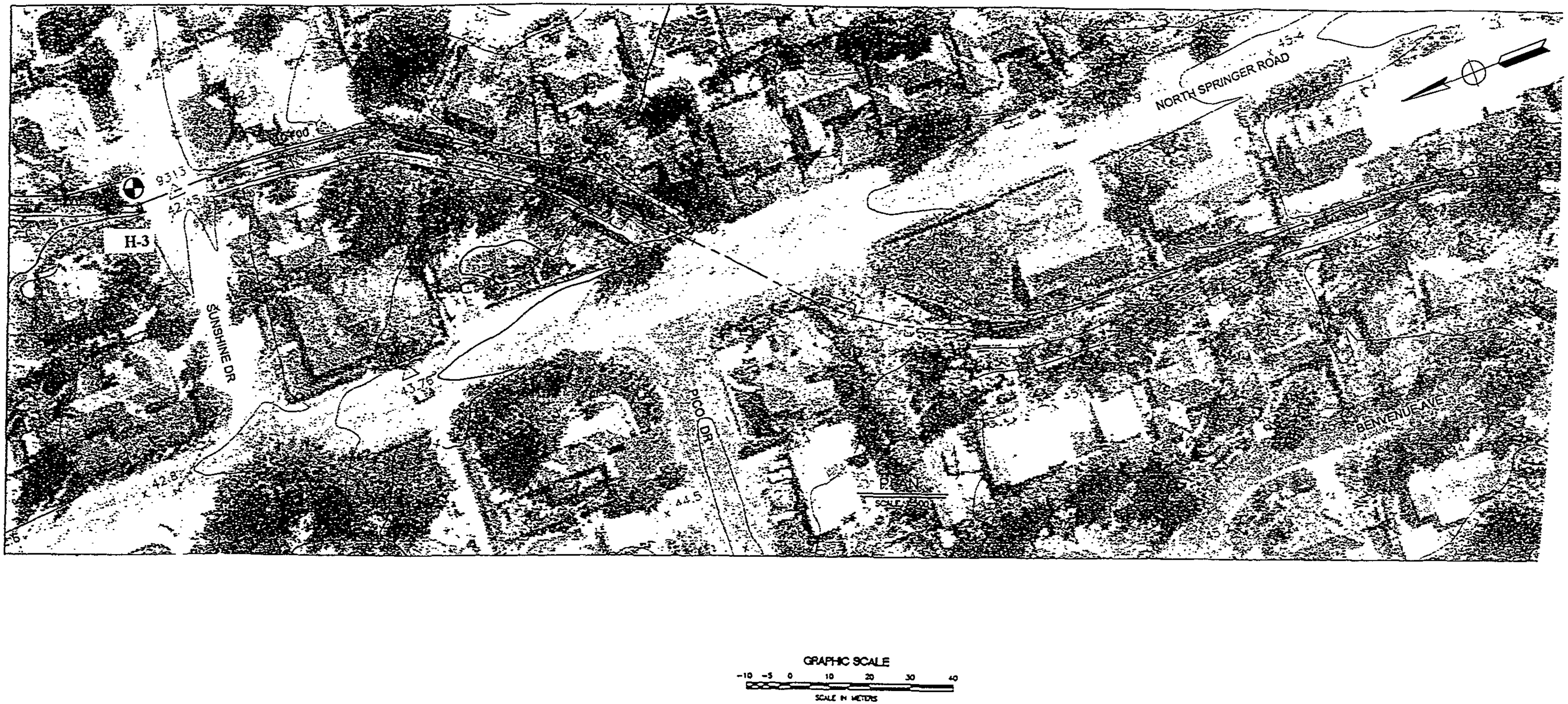
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10

PLATE NO.: 2C



SCALE: 1:1,000

SITE PLAN

SOURCE: Santa Clara Valley Water District, Map and General Plan for Permanente Creek and Hale Creek, San Francisco Bay to Foothill Expressway, Dated 3/12/99

LEGEND:

⊕ Approx. Boring Location

PARIKH CONSULTANTS, INC.
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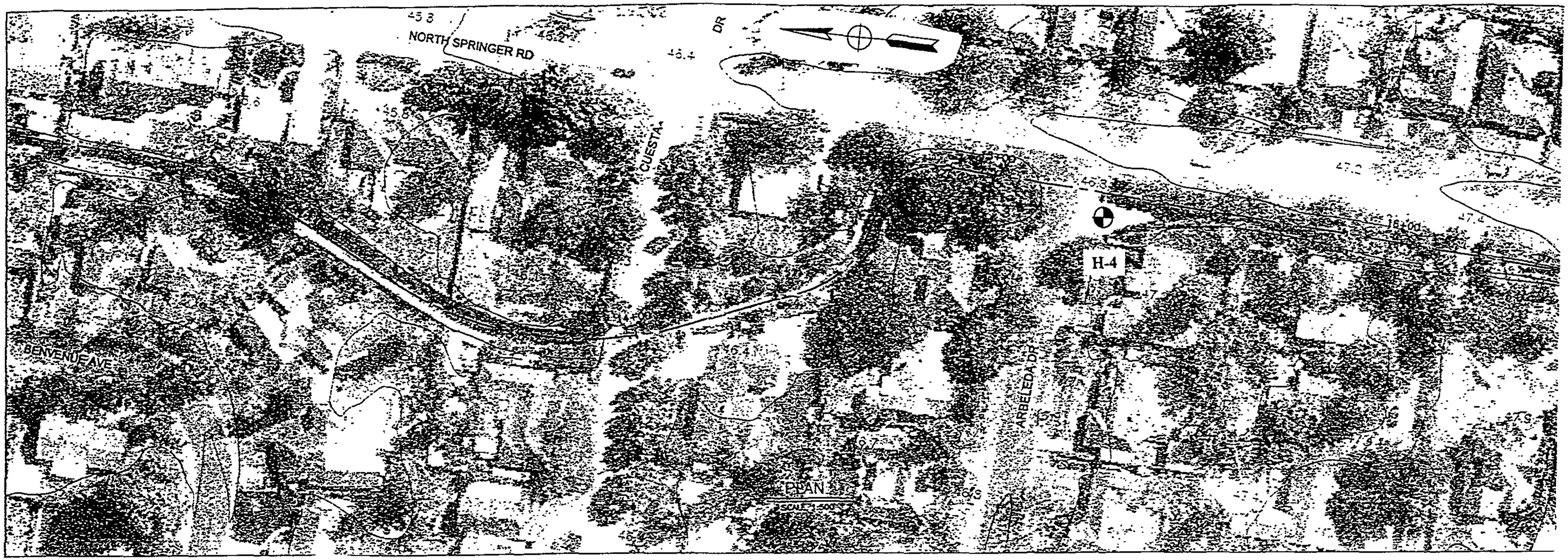
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10

PLATE NO.: 2D



GRAPHIC SCALE

-10 -5 0 10 20 30 40

SCALE IN METERS

SCALE: 1:1,000

SITE PLAN

SOURCE: Santa Clara Valley Water District, Map and General Plan for Permanente Creek and Hale Creek, San Francisco Bay to Foothill Expressway, Dated 3/12/99

LEGEND:

⊕ Approx. Boring Location

PARIKH CONSULTANTS, INC.
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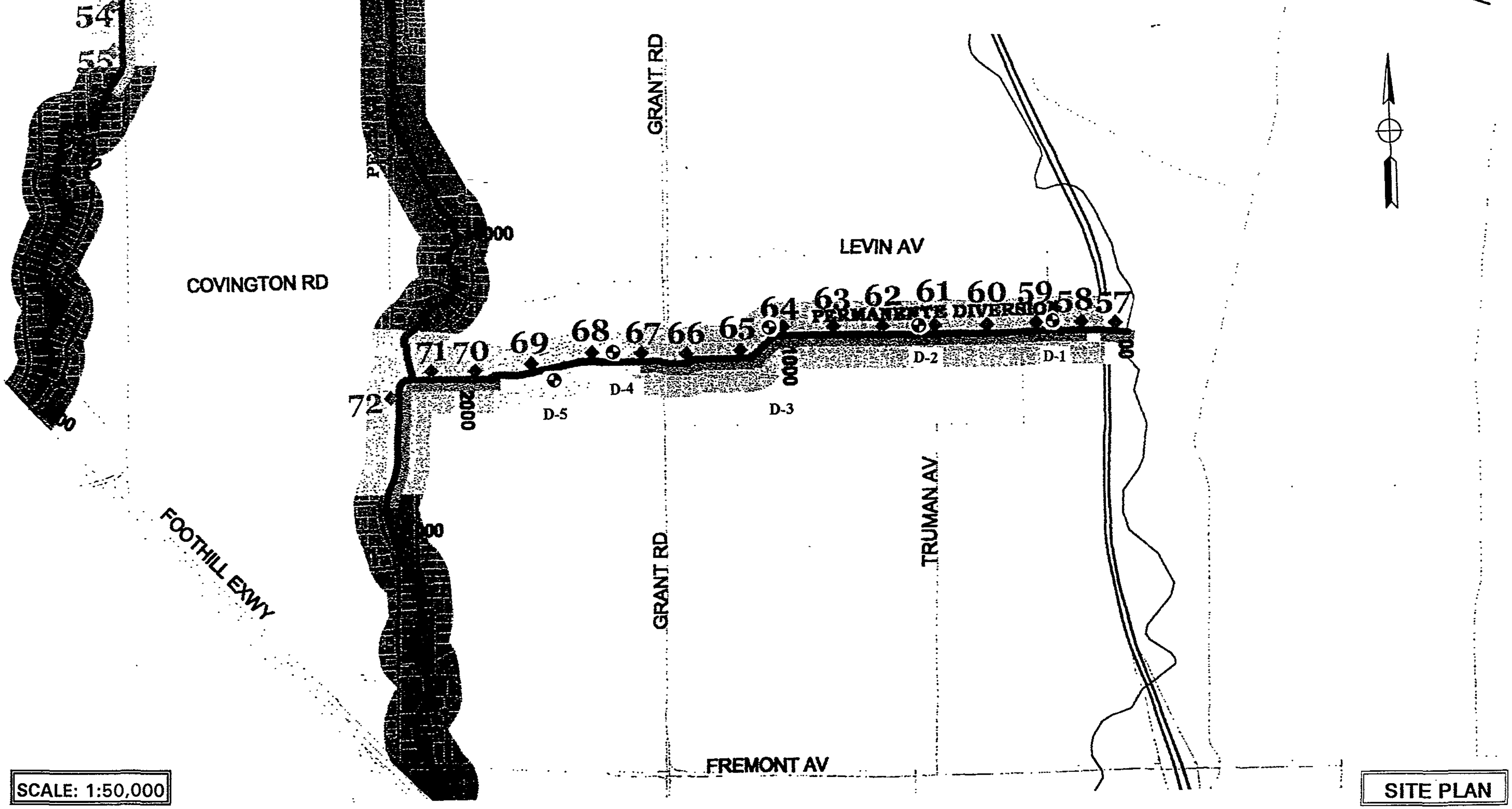
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10

PLATE NO.: 2E

PERMANENTE DIVERSION CHANNEL



SCALE: 1:50,000

SITE PLAN

LEGEND:

● Approx. Boring Location

SOURCE: Santa Clara Valley Water District, Permanente Creek Map

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS TESTING

HALE PERMANENTE CREEK PROJECT
CITY OF MOUNTAIN VIEW, CA

JOB NO.: 99106.10

PLATE NO.: 2F

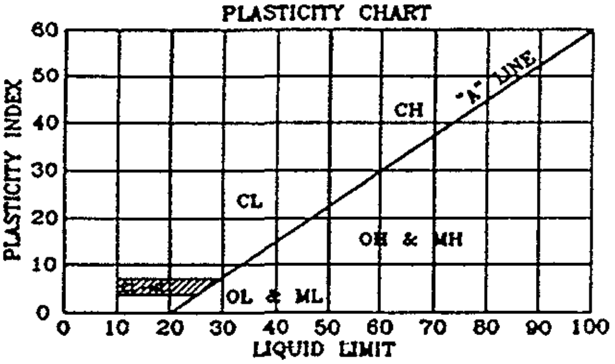
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	ILLUSTRATIVE GROUP NAMES
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Less than 5% fines	GW	Well graded gravel, Well graded gravel with sand
			GP	Poorly graded gravel, Poorly graded gravel with sand
		GRAVELS WITH FINES More than 12% fines	GM	Silty gravel, Silty gravel with sand
			GC	Clayey gravel, Clayey gravel with sand
	SANDS 50% or more of coarse fraction passing No. 4 sieve	CLEAN SANDS Less than 5% fines	SW	Well graded sand, Well graded sand with gravel
			SP	Poorly graded sand, Poorly graded sand with gravel
		SANDS WITH FINES More than 12% fines	SM	Silty sand, Silty sand with gravel
			SC	Clayey sand, Clayey sand with gravel
FINE-GRAINED SOILS 50% or more passing No. 200 sieve	SILTS AND CLAYS Liquid Limit less than 50%		ML	Silt, Sandy silt with gravel
			CL	Lean clay, Sandy lean clay with gravel
			OL	Organic clay, Sandy organic clay with gravel
	SILTS AND CLAYS Liquid Limit more than 50%		MH	Elastic silt, Sandy elastic silt with gravel
			CH	Fat clay, Sandy fat clay with gravel
			OH	Organic clay, Sandy organic clay with gravel
HIGHLY ORGANIC			PT	Peat, Highly organic silts

NOTE: 1. Coarse-grained soils receive dual symbols if: (a) their fines are CL-ML (e.g. SC-SM or GC-GM) or (b) they contain 5-12% fines (e.g. SW-SM, GP-GC, etc.). Fine-grained soils receive dual symbols if their limits plot in the hatched zone of the Plasticity Chart (CL-ML).

2. The table lists 30 out of a possible 110 Group Names, all of which are assigned to unique proportions of the constituent soils. Flow charts in ASTM D 2487-93 aid assignment of the Group Names.

PLASTICITY CHART



GRAIN SIZE CLASSIFICATION

CLASSIFICATION	US STANDARD SIEVE SIZE
BOULDERS	Above 12"
COBBLES	12" to 3"
GRAVEL Coarse Fine	 3" to 3/4" 3/4" to No. 4
SAND Coarse Medium Fine	 No. 4 to No. 10 No. 10 to No. 40 No. 40 to No.200
SILT & CLAY	Below No. 200

COHESIVE SOIL CONSISTENCY

CLASSIFICATION	UNCONFINED COMP. STRENGTH (psf)
Very Soft	< 500
Soft	500 - 1000
Medium(Firm)	1000 - 2000
Stiff	2000 - 4000
Very Stiff	4000 - 8000
Hard	> 8000

COHESIONLESS SOIL RELATIVE DENSITY

CLASSIFICATION	SPT BLOW COUNTS (Blows/ft)
Very Loose	< 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	> 50

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MATERIALS ENGINEERING

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

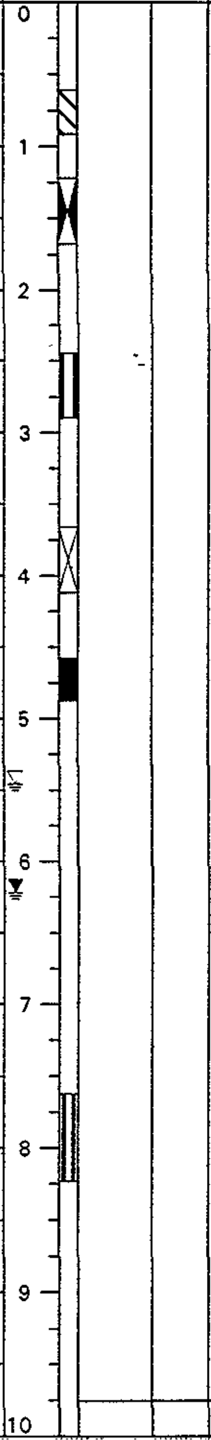
JOB NO.: 99106.10

PLATE NO: A-1A

Boring Location, Elevation & Date Drilled: ; Elev. approx. m.; drilled on	Drilling Method: -cm dia.	BORING NUMBER **LEGEND**
	Sampling Method:	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
1			22	
2	110	12	23	1.2
3	98	28	100 psi	0.8
4	-	10	35	-
5	95	20		0.7
6	-	-		12.0

Depth (m) Soil Graph & U.S.C.S.



Compressive strength as measured by Pocket Penetrometer, in tsf.	pp = 1.0tsf
2 inch I.D. California Sampler (C).	
2-1/2 inch I.D. Modified California Sampler (MC).	
3.5-inch I.D. Pitcher Tube Sampler (Cored).	
1-3/8 inch I.D. Standard Splitspoon Sampler (SPT).	
1.9 inch I.D. Hand Sampler driven with a slide hammer.	
Groundwater level first encountered during drilling	
Groundwater level at completion of boring	
Liquid Limit (LL), in percent Plasticity Index (PI), in percent	LL = 30 PI = 10
NX Core.	
Percent gravel and coarser in sample, (+#4) Percent fines (silt/clay) in sample, (-#200)	+#4 = 20% -#200 = 50%
Direct Shear Test	DS

LEGEND FOR LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

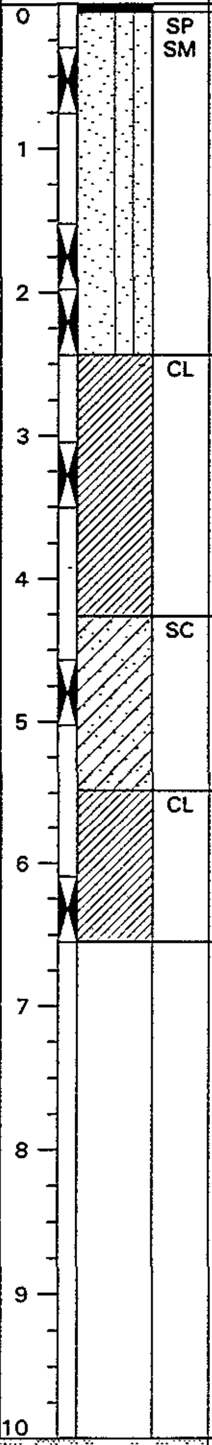
Job No.: 99106.10

This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

Plate: A-1B

..GEN 1.4.00

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-24-99	**Drilling Method:** 10-cm dia. Solid stem auger Mobile B-24 rig	**BORING NUMBER** **P-1**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1



Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)	Depth (m) Soil Graph & U.S.C.S.		
					0 SP SM	5 cm of ASPHALT	
MC-1	14.61	2	15			Angular gravel up to 38 mm at 0.3 m Light gray POORLY GRADED SAND WITH SILT, fine grained, loose, dry	
					1		
MC-2			5			Very loose	
MC-3	16.19	1	32		2	Trace fine rounded gravel, medium dense	+#4=5% -#200=7%
					CL	Brown LEAN CLAY WITH SAND, trace fine gravel, hard, moist	
MC-4	19.33	13	53	86	3		
					4		
					SC	Brown CLAYEY SAND, trace fine subrounded gravel, medium dense, moist	
MC-5	19.01	11	43		5		
					CL	Brown LEAN CLAY, trace fine sand, very stiff, moist	
MC-6	15.40	24	31		6		pp=300 kPa
						Bottom of drillhole at 6.6 m No groundwater encountered during driling	
					7		
					8		
					9		
					10		

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000 Job No.: 99106.10

1-4-00

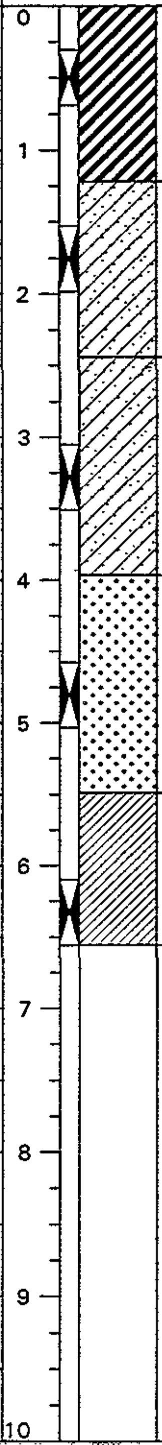
This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

Plate: A-2

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-22-99	Drilling Method: 20-cm dia. Hollow stem auger Mobile B-40 rig	BORING NUMBER **H-1**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
MC-1	17.13	13	50/12.5 cm	
MC-2	17.29	11	29	
MC-3	14.61	9	37	
MC-4	18.54	4	46	
MC-5	15.40	18	44	

Depth (m) Soil Graph & U.S.C.S.



U.S.C.S.	Description	
CH	Dark brown FAT CLAY, trace subangular gravel up to 19 mm, hard, dry to damp	
SC	Light brown CLAYEY SAND, trace gravel, sand is fine grained, medium dense, dry to damp	+#4=11% -#200=44%
SC	Brown CLAYEY SAND, sand is medium to coarse grained, trace angular to subangular gravel, medium dense, dry to damp	
SW	Brown WELL GRADED SAND WITH GRAVEL, fine to coarse sand, subangular gravel up to 25 mm, medium dense, dry	+#4=35% -#200=5%
CL	Light brown, LEAN CLAY, with concretions, very stiff, dry to damp	
	Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

1-4-00

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

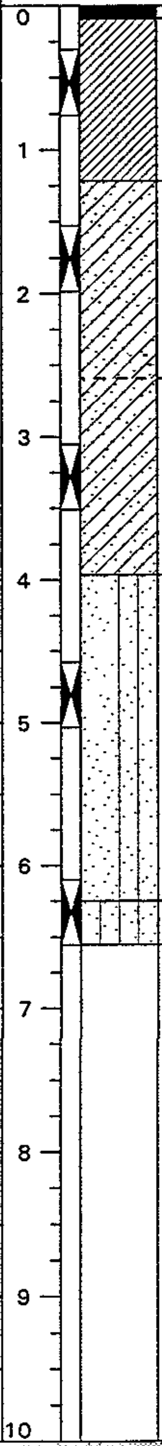
This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

Plate: A-3

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-22-99	**Drilling Method:** 20-cm dia. Hollow stem auger Mobile B-40 rig	**BORING NUMBER** **H-2**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
MC-1	17.44	15	48	
MC-2	18.23	11	36	
MC-3	18.23	11	78	
MC-4	19.80	5	73	
MC-5	17.13	15	54	

Depth (m) Soil Graph & U.S.C.S.



U.S.C.S.	Description	
	7.5 cm of ASPHALT	
CL	Dark brown LEAN CLAY, pockets of yellow fine sand, trace gravel, hard, dry to damp	
SC	Brown CLAYEY SAND, trace angular gravel up to 38 mm, pockets of fine grained yellow sand, medium dense, dry to damp	
SC	Dark brown, CLAYEY SAND WITH GRAVEL, sand is coarse grained, dense, dry	+#4=19% -#200=26%
SP SM	Brown POORLY GRADED SAND WITH SILT AND GRAVEL, gravel is subangular up to 38 mm, fine to coarse grained sand, dense, damp to moist	
SM	Brown SILTY SAND, occasional gravel, medium dense, moist	
	Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

Plate: A-4

This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

1-4 00

Boring Location, Elevation & Date Drilled:
SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-22-99

Drilling Method:
20-cm dia. Hollow stem auger
Mobile B-40 rig

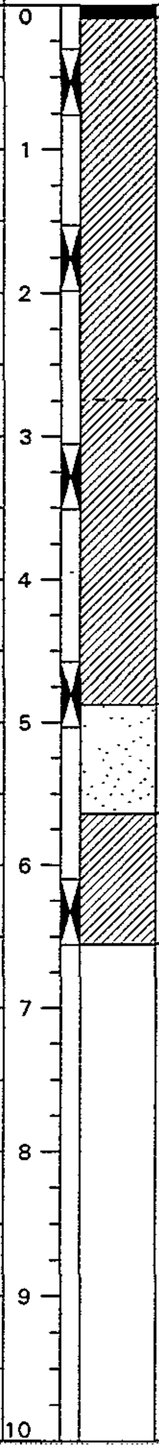
BORING NUMBER
H-3

Sampling Method:
64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.

Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
MC-1	13.36	15	12	
MC-2	15.71	16	13	
MC-3	18.86	15	55	326
MC-4	19.96	6	45	
MC-5	19.80	14	12	

Depth (m) Soil Graph & U.S.C.S.



U.S.C.S.	Description	
	7.5 cm of ASPHALT	
CL	Dark brown to brown SANDY LEAN CLAY, trace angular gravel up to 25 mm, pockets of light gray sand, firm, damp	pp = 200 kPa
	Light brown to orange, coarse sand, trace fine gravel, firm, dry to damp	pp = 400 kPa
CL	Light brown LEAN CLAY, hard, damp to moist Trace coarse sand and fine gravel at 3.5 m Trace sand	
SP	Gray, POORLY GRADED SAND, medium dense, damp to moist	
CL	Brown SANDY LEAN CLAY, trace subrounded gravel up to 38 mm, firm, moist	pp = 150 kPa
	Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

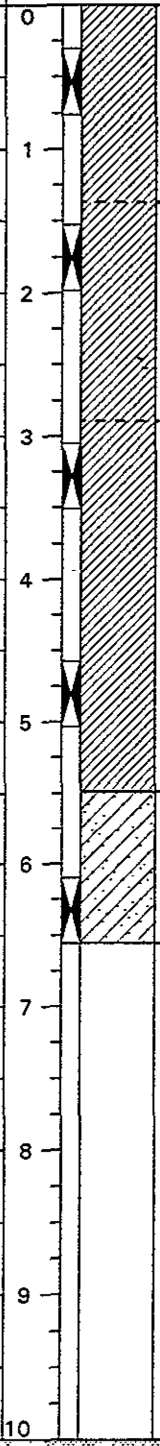
Plate: A-5

1-4-00

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-23-99	Drilling Method: 19-cm dia. Hollow stem auger Mobile B-61 rig	BORING NUMBER **H-4**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
MC-1	17.44	17	13	
MC-2	15.87	20	26	
MC-3	19.01	13	34	
MC-4	17.60	17	30	
MC-5	19.96	10	33	

Depth (m) Soil Graph & U.S.C.S.



U.S.C.S.	Description	
CL	Brown to yellowish brown LEAN CLAY, trace angular gravel up to 25 mm, firm, damp to moist	pp=200 kPa
CL	Dark brown LEAN CLAY, trace sand and angular gravel, very stiff, damp to moist	pp=400 kPa LL=46 PI=28
CL	Dark brown SANDY LEAN CLAY, sand is coarse grained and angular, trace fine subangular gravel, very stiff, damp to moist	pp=400 kPa
	Very stiff, damp to moist	
SC	Gray brown CLAYEY SAND, pockets of light brown clay, trace subangular to subrounded gravel up to 51 mm, medium dense, damp to moist	
	Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000 Job No.: 99106.10

This log is part of the report prepared by Parikh Consultants, Inc. for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

Plate: A-6

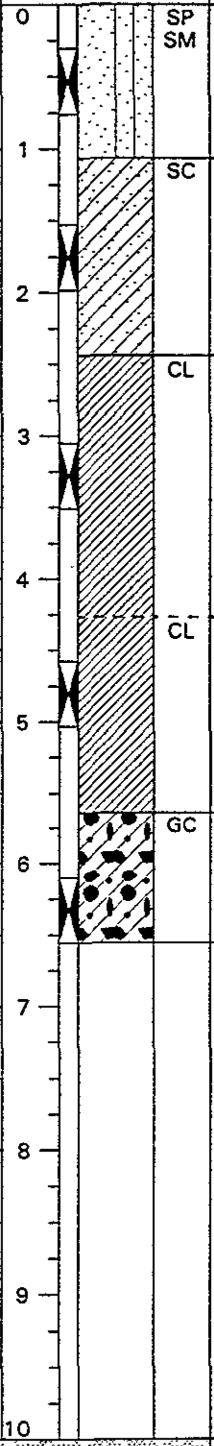
Boring Location, Elevation & Date Drilled:
SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-24-99

Drilling Method:
10-cm dia. Solid stem auger
Mobile B-24 rig

BORING NUMBER
D-1

Sampling Method:
64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.

Sheet 1 of 1



Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)	U.S.C.S.	Description	
MC-1	-	3	48		SP SM	Subrounded gravel at top 5-8 cm Dark brown POORLY GRADED SAND WITH SILT AND GRAVEL, subrounded gravel up to 25 mm, medium dense, dry	
MC-2	-	7	6		SC	Dark brown to brown CLAYEY SAND WITH GRAVEL, fine to coarse grained sand, very loose, damp	
MC-3	-	8	22		CL	Brown to dark brown SANDY LEAN CLAY, trace subrounded fine grained gravel, sand is medium to coarse grained, stiff, damp	
MC-4	19.33	12	15		CL	Brown to yellowish brown LEAN CLAY WITH SAND, trace gravel, sand is medium to coarse grained, stiff, damp to moist Lense of poorly graded sand with clay and gravel at 5 m	pp=425 kPa
MC-5	19.80	13	18		GC	Brown CLAYEY GRAVEL, gravel is rounded up to 51 mm, pockets of red fine sand, loose, moist	
						Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

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Plate:
A-7

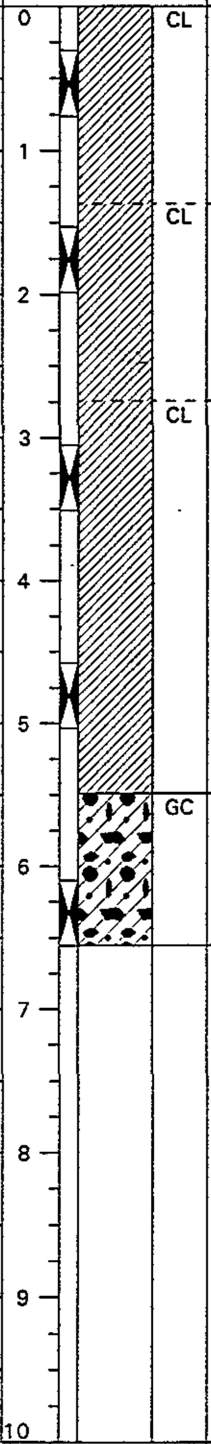
Boring Location, Elevation & Date Drilled:
SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-24-99

Drilling Method:
10-cm dia. Solid stem auger
Mobile B-24 rig

BORING NUMBER
D-2

Sampling Method:
64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.

Sheet 1 of 1



Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)	U.S.C.S.	Description	
MC-1	19.64	10	41		CL	Subrounded gravel at top 5 cm Brown SANDY LEAN CLAY, trace subrounded gravel up to 38 mm, very stiff, damp	
MC-2	17.76	13	23	431	CL	Brown LEAN CLAY, pockets of yellow fine sand, stiff, damp	
MC-3	19.96	10	18		CL	Dark brown to brown SANDY LEAN CLAY, trace subrounded to rounded gravel up to 13 mm, stiff, damp	
MC-4	16.66	17	20			Dark brown, stiff, moist	pp=250 kPa
MC-5	19.17	6	68		GC	Gray with brown mottled, CLAYEY GRAVEL WITH SAND, gravel is subrounded up to 38 mm, pockets of yellow sand, pieces of friable sandstone, dense, dry to damp	
						Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000
Job No.: 99106.10

1-4-00

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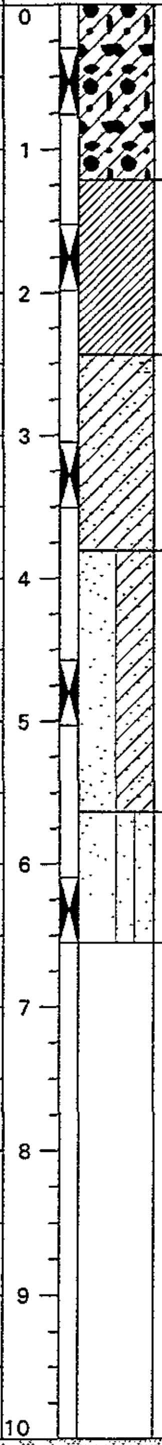
Plate:
A-8

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-24-99	Drilling Method: 10-cm dia. Solid stem auger Mobile B-24 rig	BORING NUMBER **D-3**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)
MC-1	-	7	14	
MC-2	18.23	14	12	
MC-3	19.17	11	15	
MC-4	18.86	8	12	
MC-5	18.39	5	44	

Depth (m) Soil Graph & U.S.C.S.



U.S.C.S.	Description	
GC	Gravel at top 7.5 cm Brown CLAYEY GRAVEL, gravel is subrounded up to 19 mm, occasional sand, loose, dry	
CL	Dark brown to brown LEAN CLAY WITH SAND, sand is yellow and fine grained, trace gravel up to 51 mm, firm, damp to moist	pp = 300 kPa
SC	Brown CLAYEY SAND, trace fine gravel, loose, damp	+#4 = 7% -#200 = 40%
SP SC	Cobbles and gravel between 3.8 and 4.6 m Dark brown POORLY GRADED SAND WITH CLAY, trace subrounded gravel up to 38 mm, loose, damp to moist	
SP SM	Brown POORLY GRADED SAND WITH SILT AND GRAVEL, sand is fine to coarse grained, pieces od yellow friable sandstone, medium dense, damp to moist	
	Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

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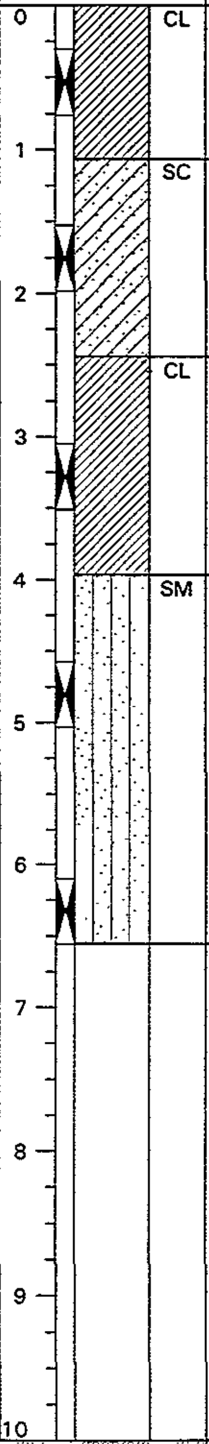
Plate:
A-9

HALEP 1:4:00

Boring Location, Elevation & Date Drilled: SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-23-99	**Drilling Method:** 19-cm dia. Hollow stem auger Mobile B-61 rig	**BORING NUMBER** **D-4**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)	U.S.C.S.	Description	
MC-1	18.39	9	58		CL	Dark brown SANDY LEAN CLAY, trace gravel, hard, dry	
MC-2	14.77	6	24		SC	Brown CLAYEY SAND, trace subangular gravel, medium dense, dry	
MC-3	18.70	13	85		CL	Brown to light brown LEAN CLAY, trace yellow fine sand, hard, dry	LL=43 PI=24
MC-4	16.66	9	53		SM	Brown to yellowish brown SILTY SAND WITH GRAVEL, gravel is subangular up to 25 mm, medium dense, dry	+#4=18% -#200=14%
MC-5	-	5	68			Dense, dry	
						Bottom of drillhole at 6.6 m No groundwater encountered during drilling	

Depth (m) Soil Graph & U.S.C.S.



LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000 | Job No.: 99106.10

1-4-00

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Plate:
A-10

Boring Location, Elevation & Date Drilled:	Drilling Method:	BORING NUMBER
SEE ATTACHED SITE PLAN; Elev. approx. m.; drilled on 9-24-99	10-cm dia. Solid stem auger Mobile B-24 rig	**D-5**
	Sampling Method: 64 mm I.D. Mod. Calif. (MC), 64 kg (140 lbs) hammer, 76 cm (30 inch) drop.	Sheet 1 of 1

Sample Type & No.	Dry Density (kN/m3)	Water Content (%)	Blows Per 30 cm	Compress. Strength (kPa)	Depth (m)	Soil Graph & U.S.C.S.		
					0	CL	Subangular gravel up to 51 mm at top	
MC-1	19.33	11	44				Dark brown LEAN CLAY WITH SAND, trace gravel up to 19 mm, very stiff, dry to damp	
					1			
						CL	Brown SANDY LEAN CLAY, trace gravel, soft, damp to moist	
MC-2	18.86	15	5					pp=125 kPa
					2			
						SM	Light brown SILTY SAND WITH GRAVEL, fine to coarse grained sand, subangular gravel up to 25 mm, loose, dry	
MC-3	19.80	3	20		3			+#4=32% -#200=14%
					4			
MC-4	18.39	13	26				Brown to yellowish brown, medium dense, damp	
					5			
						SP SM	Brown, POORLY GRADED SAND WITH SILT, trace subrounded gravel up to 19 mm, medium dense, damp	
MC-5	19.80	6	54		6			
							Bottom of drillhole at 6.6 m No groundwater encountered during drilling	
					7			
					8			
					9			
					10			

LOG OF BORING

PARIKH CONSULTANTS, INC.
Geotechnical & Materials Engineering

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

Date: 1/2000

Job No.: 99106.10

1-4-00

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Plate:

A-11

LABORATORY TESTS

Classification Tests

The field classification of the samples was visually verified in the laboratory according to the Unified Soil Classification System. The results are presented on "Log of Borings", Appendix A.

Moisture-Density

The natural moisture contents and dry unit weights were determined for selected undisturbed samples of the soils in general accordance with ASTM Test Method D 2216-92. This information was used to classify and correlate the soils. The results are presented at the appropriate depths on the "Log of Borings", Appendix A.

Atterberg Limits

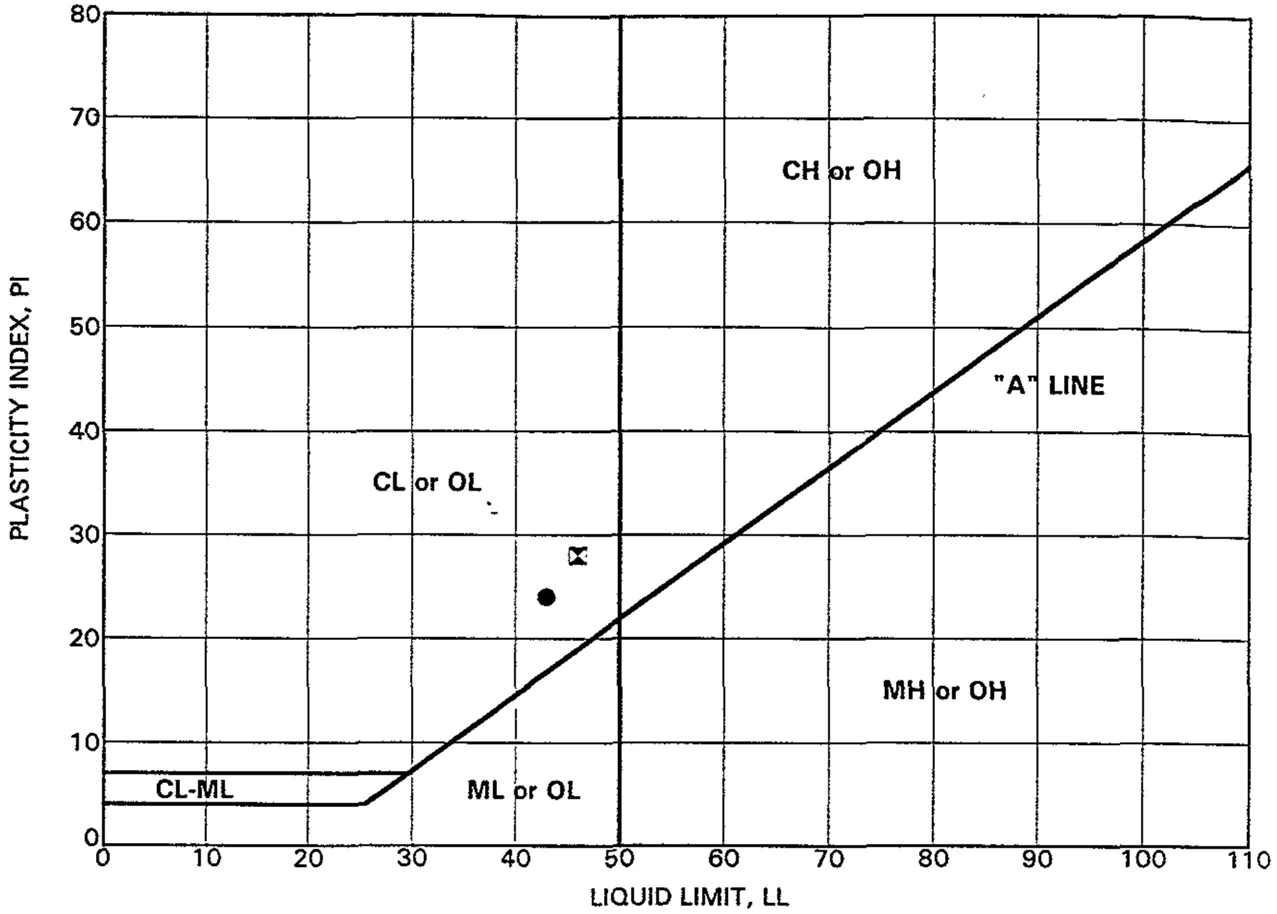
The Atterberg Limits were determined for selected samples of the fine-grained materials. These results were used to classify the soils, as well as to obtain an indication of the expansion potential with variations in moisture content. The Atterberg Limits were determined in general accordance with ASTM Test Method D 4318-93. The results of these tests are presented on Plate B-2, "Plasticity Chart".

Grain Size Classification

Grain size classification tests (ASTM Test Method D 422-63) were performed on selected samples of granular soil to aid in the classification. The results are presented on Plates B-3A to B-3B, "Grain Size Distribution Curves".

Unconfined Compression Tests

Strength tests were performed on selected undisturbed sample using unconfined compression machine. Unconfined compression test was performed in general accordance with ASTM Test Method D 2166-91. The results are presented on "Log of Borings", Appendix A.



PLASTICITY CHART

Boring Number	Sample Number	Depth (m)	Test Symbol	Moisture Content (%)	LL	PL	PI	Description
D-4	MC-3	3.4	●	MC-3	43	19	24	LEAN CLAY (CL)
H-4	MC-2	1.8	⧗	MC-2	46	18	28	LEAN CLAY (CL)

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

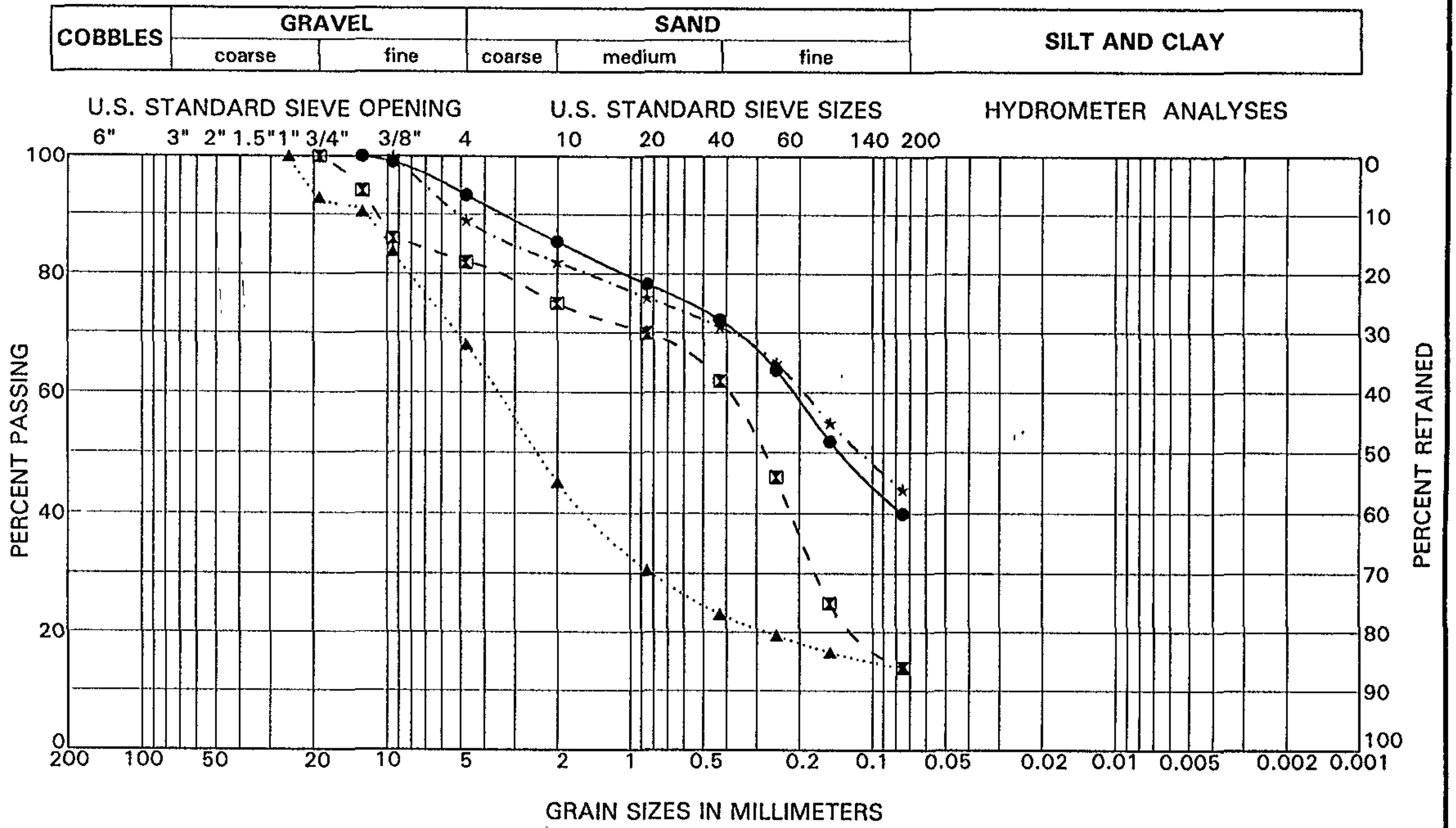
HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

JOB NO: 99106.10

PLATE NO: B-2

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

GRAIN SIZE DISTRIBUTION CURVES



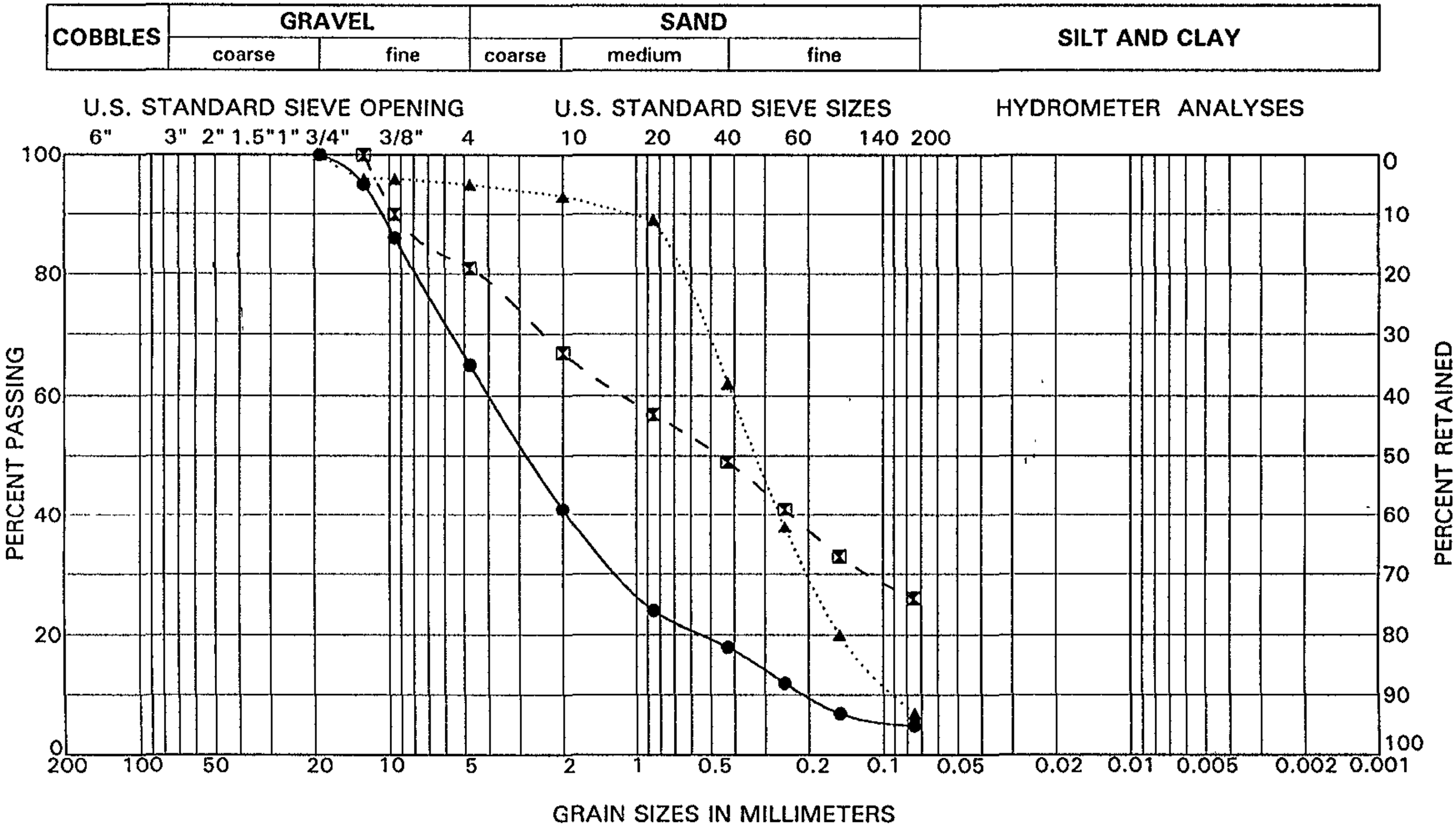
Boring Number	Sample Number	Depth (m)	Symbol	LL	PI	Description
D-3	MC-3	3.4	●			CLAYEY SAND (SC)
D-4	MC-4	4.9	⊠			SILTY SAND WITH GRAVEL (SM)
D-5	MC-3	3.4	▲			SILTY SAND WITH GRAVEL (SM)
H-1	MC-2	1.8	★			CLAYEY SAND (SC)

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

JOB NO: 99106.10

PLATE NO: B-3A

GRAIN SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (m)	Symbol	LL	PI	Description
H-1	MC-4	4.9	●			WELL GRADED SAND WITH GRAVEL
H-2	MC-3	3.4	⊠			CLAYEY SAND WITH GRAVEL
P-1	MC-3	2.3	▲			POORLY GRADED SAND WITH SILT (SP-SM)

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

HALE PERMANENTE CREEK PROJECT
MOUNTAIN VIEW, CA

JOB NO: 99106.10

PLATE NO: B-3B

NORCAL GEOPHYSICAL CONSULTANTS, INC.

August 23, 1999

Mr. Hemang Desai
PARIKH Consultants, Inc.
481 Valley Way, Building 1
Milpitas, CA 95035-4016

Dear Mr. Desai:

This report presents the findings of a geophysical investigation performed by NORCAL Geophysical Consultants, Inc. along portions of Hale and Permanente Creeks in Mountain View and Los Altos, California. The field survey was conducted on August 3 and 4, 1999 by NORCAL Geophysicist Donald J. Kirker, and geophysical technician Travis Black. Logistical support was provided by Hemang Desai of PARIKH Consultants, Inc.

SITE DESCRIPTION

Permanente and Hale Creeks are small creeks that flow north from the foothills of Los Altos. Permanente Creek extends from the foothills to the San Francisco Bay. Hale Creek merges with Permanente Creek near the base of the foothills. Each creek flows naturally until they reach the city of Los Altos, where portions of each creek become channelized with reinforced concrete.

The area of investigation, as specified by PARIKH Consultants, Inc., includes the channelized sections between Highway 101 to the north and the Foothill Expressway to the south. These channels comprise approximately 2/3 of the total length of the creeks within the survey area. Permanente Creek is channelized from the confluence of both creeks to Highway 101. Within this segment, the creek becomes enclosed for several thousand feet. South of the confluence, Permanente Creek is channelized for approximately 1,500 lineal feet. Hale Creek is channelized south of the confluence approximately 5,576 lineal feet. Both channels are approximately 8 to 15 feet wide, 6 to 8 feet deep and are generally clear of above ground obstructions and debris. However, a significant portion of Permanente Creek contains water, silt, and thick moss. Specifically, the channelized section south of the confluence and all of the channel from the enclosure to Highway 101 contain significant amounts of water and silt.

PURPOSE

Because of the age of the channels, the structural integrity of their concrete lining is in question. Furthermore, suspicions have been aroused that the flow of water through these channels may be producing voids beneath the concrete lining. Therefore, the purpose of this survey is to obtain shallow subsurface information that will aid in determining the presence and extent of possible voids beneath the concrete lining.

SCOPE OF WORK

NORCAL's scope of work for this project consists of acquiring GPR data along the bottom of the concrete lined portions of each creek within the designated survey area. Our scope also includes interpreting and tabulating the data and presenting our findings in a written report.

GPR METHODOLOGY

Ground penetrating radar is a method that provides a continuous, high resolution cross-section depicting variations in the electrical properties of the shallow subsurface. The method is particularly sensitive to variations in electrical conductivity and electrical permittivity (the ability of a material to hold a charge when an electrical field is applied).

The system operates by continuously radiating an electromagnetic pulse into the ground from a transducer (antenna) as it is moved along a traverse. Since concrete and asphalt, as well as other earth materials are transparent to electromagnetic energy, only a portion of the radar signal is reflected back to the surface from interfaces representing variations in electrical properties. When the signal encounters metal (such as rebar), however, all of the incident energy is reflected. The reflected signals are received by the same transducer and are printed in cross-section form on a graphical recorder. Changes in subsurface reflection character on the GPR records can provide information regarding the location of voids, rebar, concrete thickness, site material variations, and other features. The detection and resolution of voids is dependant upon the electrical properties of the material above the void, as described above, the size of the void, and whether or not the void is filled with fluid. Typically, fluid filled voids will produce strong, well defined, reflection patterns.

We used a Geophysical Survey Systems, Inc. SIR-2 Subsurface Interface Radar System equipped with a 900 megahertz (MHz) antenna. This antenna is in the high frequency range and is used to provide high resolution at very shallow depths. Generally, electrically conductive materials, or significant amounts of rebar can reduce the penetration capability and limit radar performance.

DATA ACQUISITION

Horizontal Control

We based data acquisition on a horizontal control grid that was marked by others on the side walls of each channel. Along Permanente Creek, the grid was marked every 100 meters (328 feet) with the origin located near the mouth of the creek at the San Francisco Bay. On Hale Creek, the grid was marked every 100 feet with the origin located at the confluence of Hale and Permanente Creeks. Both grids increase to the south.

Geophysical Survey

Prior to data acquisition, we conducted test over areas covered with water, saturated mud, and moss. The results of these tests indicated that the moisture associated with these features caused substantial interference with the radar signal. Therefore, GPR data could not be obtained along Permanente Creek from the south entrance of the enclosure (El Camino Real) to Highway 101 and along the channelized portion of Permanente Creek south of the confluence.

We did obtain GPR data along the remaining portions of the channels, which covered approximately 8,300 lineal feet. GPR data were obtained along three traverses that were positioned approximately 1 to 2 feet from each side wall and in the center of the channel. To increase efficiency of data acquisition along each channel, the GPR system was set up on an All Terrain Vehicle (ATV). The ATV was moved down the center of each creek as the antenna was pulled slowly over each traverse.

DATA ANALYSIS

We examined the GPR records for reflection patterns characteristic of voids. Voids can be manifested in different ways depending upon the composition of the subsurface materials and whether or not the voids are air or water filled. Generally, air filled voids produce a lack of reflection patterns, and water filled voids produce strong continuous reflection patterns. We also examined the records for patterns associated with the concrete lining. These patterns include continuous (horizontal) reflections and strong hyperbolic reflection patterns. The continuous patterns represent the pavement surface. The strong hyperbolic reflection patterns are indicative of the steel reinforcing bars (rebar) in the concrete. Continuous patterns associated with the base of the concrete were also evident on these records. However, they were very subtle. This may be due to masking effects caused by the closely spaced rebar. It should be noted, that the closely spaced rebar may also mask effects from possible voids beneath the lining.

RESULTS

Our analysis of the GPR records obtained along Hale and Permanente Creeks define reflection patterns characteristic of variable subsurface conditions. These patterns include subtle continuous reflections that we interpret as being related to possible voids or saturated soils beneath the concrete lining. Other patterns evident on the GPR records include strong hyperbolic reflections typical of the rebar in the concrete, and continuous reflection horizons that we interpret as being associated with the interface between the concrete slab and fill material. In addition, discontinuous reflection patterns are evident in the data which we interpret as being associated with the fill material located beneath the concrete lining.

The reflection patterns that we interpret as possibly being related to voids are primarily evident on the records obtained along Hale Creek. They generally occur in the center of the channel and comprise zones that measure from 1 foot to more than 16 feet in length. It should be noted that these reflection patterns are not unique to voids and may also represent saturated soils. Since there were no known voids to conduct tests over, we recommend that some of these locations be further investigated intrusively to characterize whether or not they are void related. A list of these locations are presented below.

HALE CREEK

Center Profile (ft):	9-26, 68-75, 133-138, 155-164, 277-283, 338-343, 357-361, 377-393, 451-454, 519-520, 591-593, 705-707, 713-718, 845-855, 867-870, 877-881, 886-898, 918-929, 965-967, 993-995, 1061-1063, 1525-1528, 1556-1563, 1594-1596, 1605-1607, 1947-1953, 1959-1969, 2279-2281, 2538-2553, 2569-2581, 2863-2864, 4398-4402
East Profile (ft):	135-137, 216-218, 221-225, 743-750, 845-850, 917-927, 1121-1127, 1131-1134, 3381-3390, 3586-3595
West Profile (ft):	1900-1905, 1909-1920, 1927-1939

PERMANENTE CREEK

The portion of channel surveyed along Permanente Creek do not indicate any unusual or anomalous reflections that we interpret as possibly being void related. However, based on past experience, voids less than approximately 1 to 2 inches in height could go undetected in areas overlain with significant rebar or where electrical property contrasts are minimal.

STANDARD CARE AND WARRANTY

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the shallow subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the level of skill ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate having the opportunity to provide our services to PARIKH Consultants, Inc. on this project.

Respectfully,

NORCAL Geophysical Consultants, Inc.

Donald J. Kirker

Donald J. Kirker
Geophysicist, GP-997

DJK/jh

AnaCon Testing Laboratories, Inc.

415 Fairchild Drive
Telephone: (650) 335-1233

Mountain View, California 94043
Facsimile: (650) 335-1076

September 20, 1999 / ld

Parikh Consultants, Inc.
481 Valley Way
Milpitas, California 95035

ATL No.: 0036.01
Lab No.: 39093.1.6

Attention: Prav Dayam

Service: CHLORIDE & SULFATE TESTS

Job No.: 99106.10 - Permanente Creek - SIX COMPOSITES: BC-1; BC-2
AC-1; AC-2
CC-1; CC-2.

Date Received: September 16, 1999

Sample Identification:	Water Soluble Chloride* Found	Water Soluble Sulfate** Found
BC-1	4.8	43.2
BC-2	7.2	25.9
AC-1	3.0	66.2
AC-2	5.4	43.2
CC-1	9.3	31.6
CC-2	7.2	21.6

*Water Soluble Chloride, mg Cl/Kg Soil: Requirement - 500 max. Calif. Test Method 422

**Water Soluble Sulfate, mg SO_4/Kg Soil: Requirement - 2000 max. Calif. Test Method 417

Respectfully submitted,
AnaCon Testing Laboratories, Inc.

Louis Davis
Chemistry Laboratory

Summary of Corrosion Test Results

Sample No	*Sample Description*	*Location*	*Resistivity (ohm-cm)*	*pH*	*Sulfate Content (ppm)*	*Chloride Content (ppm)*
AC-1	Composite of samples collected at Sta. 0+00, 0+20, 10+00, 30+00, 40+00 50+00	Permanente Creek	1700	8.0	66.2	3.0
AC-2	Composite of samples collected at Sta. 76+80, 110+00, 114+70, 120+60 129+00	Permanente Creek	2700	7.7	43.2	5.4
BC-1	Composite of samples collected at Sta. 10+00, 20+00, 18+90, 30+00	Diversion Structure	2334	8.0	43.2	4.8
BC-2	Composite of samples collected at Sta. 50+00, 40+00, 80+70	Diversion Structure	2268	7.9	25.9	7.2
CC-1	Composite of samples collected at Sta. 17+00, 25+00, 35+00, 45+00	Hale Creek	1600	7.3	31.6	9.3
CC-2	Sample at 55+00	Hale Creek	1300	7.1	21.6	7.2

CORROSION INVESTIGATION
OF REINFORCED CONCRETE
SIDE WALLS AND BOTTOM SLAB

AT THE PERMANENTE CREEK
MOUNTAIN VIEW, CALIFORNIA

PREPARED FOR:

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EXECUTIVE SUMMARY

V & A Consulting Engineers (V & A) was retained by Parikh Consultants to perform half-cell potential testing of selected areas of the reinforced concrete side walls and bottom slab of the Permanente Creek, Hale Creek and Permanente Diversion Creek in Moutain View, California. Ten test locations were selected by Parikh Consultants. V & A performed visual inspection, testing of electrical continuity and measurement of half-cell potentials at the selected locations. The testing was performed in October 1999.

The results of the investigation indicate that corrosion may be occurring on the reinforcing steel at six of the ten tested locations. Corrosion of the reinforcing steel at the bottom of the side walls is believed to be the result of differential aeration at the creek water level. Corrosion was probably due to concrete cracking at two locations. The findings are summarized in the table below:

Test Location	Concrete Condition	Corrosion on bottom of wall	Corrosion at crack	Other Corrosion	No Corrosion	Uncertain Corrosion Condition
1	Wide cracks, rust staining at fine cracks	X	X			
2	Good				X	
3	Good, next to spalled concrete	X	At spalled area			
4	Hairline cracks and brown staining		X	Spread out		X*
5	Hairline cracks and brown staining	X				
6	Hairline cracks and brown staining				X	Verify carbonation
7	Good				X	
8	Good	X		Near top of wall		
9	Good					X
10	Good	X		Several locations		

* *It is uncertain whether corrosion was due to cracking at this location.*

Due to the variety of configurations and exposures, the present results are not representative of the entire creek. The construction history of the walls and slabs along the three branches of the creek should be reviewed, and additional testing performed accordingly. The depth of carbonation and the levels of chloride in the concrete should be measured. This data should be used in combination with the half-cell potential testing to evaluate the condition of the reinforcing steel. Corrosion activity at the time of testing was expected to be the lowest of the year due to the low moisture levels in the soil and concrete.

The recommendations for remedial measures include concrete repair and consideration of the installation of cathodic protection on the wall surfaces to provide protection to the reinforcing steel.

CONCLUSIONS

- Corrosion was suspected near the bottom of the wall at Locations No. 1, 3, 5, 8 and 10, which appeared to correspond to the creek water level based on visual observations. This type of corrosion activity was probably due to differential aeration between the reinforcement under water and above the water level.

- At Locations No. 1 and 4, some corrosion seemed to be due to concrete cracking.

- At Locations No. 2, 6, and 7, corrosion appeared to not have initiated.

- These conclusions are based on the assumptions that concrete carbonation, if any, did not affect the measurements and that chloride levels in concrete were low.

- All reinforcement in the test areas was electrically continuous.

- Testing was performed at a time when corrosion is expected to be minimal due to low moisture levels in the soil and concrete.

- Testing was performed at ten locations. These results are not believed to be representative of the condition of the entire creek.

RECOMMENDATIONS

- Carbonation depth and chloride content in concrete should be measured at a representative number of locations.

- Further analysis should be performed to determine the extent of the corrosion of the reinforcing steel in the Permanente, Permanente Diversion and Hale Creeks, based on construction history and concrete wall exposures.

- Testing should be performed at the end of the wet season to obtain data that is more representative of worst conditions.

- Consideration should be given to the repair of damaged concrete and the installation of a cathodic protection system to protect the reinforcing steel. The systems under consideration should include spray applied zinc and mesh type anodes. The zinc system should address the possibility of galvanic operation as well as utilizing impressed current.

TESTING METHODS

Visual Inspection and Delamination Testing

Each test location was visually inspected and tested for delamination. Delamination was determined by sounding. Cracks, spalled and delaminated concrete and rust staining were noted and used for analysis of the half-cell potential data. The depth of concrete cover was measured at all exposed locations. The visual inspection results are included in Tables 1 through 10.

Electrical Continuity Testing

Measurement of half-cell potentials is representative of corrosion activity only if the reinforcing steel in the concrete is electrically continuous. The reinforcing steel was exposed by Parikh Consultants at two diagonal corners of each testing area. Electrical continuity of the reinforcing steel was tested between the two exposed corners by measuring resistance and potential difference between the two exposed locations. Testing was performed with a high input-impedance voltmeter. The steel is considered continuous when the potential difference is less than 0.01 mV and the resistance is less than 10 ohms. A Nillson meter was also used to measure resistance of the reinforcement. The measurements indicated that electrical continuity exists between the reinforcing steel measured. The potential difference and resistance data is shown in Tables 1 to 10.

Half-cell Potential Testing

Half-cell potentials were measured on the side walls and on the bottom slab of the creek. The measurements were taken in grid patterns that reflect the reinforcement spacing at each location. A schematic of the test setup is shown in Figure 21. The concrete surface was wetted to provide stability in the half-cell potentials. The half-cell potential data is shown in Tables 1 through 10 and Figures 1 to 10. Potential differentials are shown graphically in Figures 11 to 20. The electrical connection to the reinforcing steel was made at the exposed locations. The reinforcement spacing was provided to V & A by Parikh Consultants. The location of the exposed reinforcement, the maximum and minimum half cell potential values, and the standard deviation of the measurements are shown in Tables 1 through 10.

ASTM C876 suggests that there is a 90 percent probability that no corrosion is occurring where the measured potential is less negative than -200 millivolts, versus copper-copper sulfate (CSE). The test method further states that, where the potential is more negative than -350 millivolts (CSE), there is a greater than 90 percent probability that corrosion is occurring and, where the potential lies between -200 and -350 millivolts (CSE), corrosion is uncertain.

Corrosion is driven, in part, by variations in the potential on the surface of the material under study. It is therefore also important to note the differences in potential measurements for the individual grid areas, as well as the differences in potential measurements along the creek.

Half-cell potential measurements do not always indicate the presence of corrosion current. For instance, concrete that is saturated with water or carbonated at the depth of the reinforcing steel may alter the half-cell potential measurements and the above-mentioned ASTM C876 guidelines may not be applicable.

For the present study, the carbonation depth and chloride content in the concrete were not measured for this project. Therefore, the results were interpreted under the assumption that concrete carbonation, if any, did not affect the measurements and that the chloride content was low. **V & A strongly recommends that carbonation depth and chloride content be measured to confirm the test results.**

RESULTS AND DISCUSSION

All test results are shown in Tables 1 to 10, Figures 1 to 20 and Photos 1 to 19. The data at each test location is discussed below.

Reinforcing steel in concrete is normally passivated by a passive film that is formed under the high pH conditions (12.5 to 13.8) existing within the concrete. However, this protection against corrosion can be compromised by carbonation or by the ingress or addition of chlorine ions, or both. With time, carbonation may occur according to the reaction

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O,$$

resulting in a reduction of pH between 8 and 9 where the passive film is no longer stable. When present in concrete above a critical concentration, chlorine ions initiate corrosion by locally breaking down the passive film and inducing pitting corrosion. The attack may subsequently spread and become relatively uniform. In either case (carbonation or chloride intrusion), solid corrosion products are generated at the steel-concrete interface. Since these normally occupy a greater volume than the parent metal, they give rise to tensile hoop stresses and in time to concrete cracking and spalling.

Variations of half-cell potential measurements may indicate galvanic corrosion cells, with the corrosion activity occurring at the areas of highest potential within the test grid.

From the electrical continuity measurements taken at the various core locations, all of the reinforcing steel in the tested locations appears to be electrically continuous.

Due to the variety of configurations and exposures, the present results are not representative of the entire creek. The construction history of the walls and slabs along the three branches of the creek should be reviewed, and additional testing performed accordingly.

Testing was performed in October, before the rainy season. The concrete and soil moisture was low. Corrosion activity at the time of testing was expected to be the lowest of the year.

Location No. 1: Hale 5+00 Left Wall

Location No. 1 exhibited considerable cracking with cracks as wide as 1/16 inch. No delamination was found. Some rust bleeding was found at fine cracks at the bottom of the wall. Concrete erosion was evident at the bottom of the wall.

Half-cell potential data ranged from –128 to –299 mV (CSE). The regions of most negative potentials were located near a vertical crack in the middle of the wall and at the bottom of the wall. Based on the testing results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion appears to have initiated near the widest vertical crack and at the bottom of the wall.

Location No. 2: Hale 1+52 Right Wall

Concrete at Location No. 2 was in good condition. Upon visual inspection, the exposed reinforcement was not corroding.

The half-cell potential measurements ranged from –61 to –214 mV (CSE). Based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion appears not to have initiated at the tested location.

Location No. 3: Hale 9+15 Left Wall

Test Location No. 3 was situated on the right hand side of severe spalling, as shown in Photos No. 1 and 2. The exposed reinforcement at the lower right hand corner was in good condition. The exposed reinforcement at the spalled area was actively corroding.

The half-cell potential results ranged from –158 to –375 mV (CSE). The most negative potentials were found at 16 inches from the bottom of the wall. Based on the testing results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion appeared to be occurring near the bottom of the wall. It should be noted that the concrete was not severely damaged at the location of highest corrosion activity.

Location No. 4: Diversion 3+79 Left Wall

Location No. 4 is shown in Photos No. 3 and 4. The expected #5 reinforcement was not found. A welded wire mesh was exposed and tested at this location. The exposed welded wire mesh was in good condition. A cross-shaped hairline crack was present in the middle of the tested area. Some brown staining was apparent at the vertical crack.

The half-cell potential data ranged from –300 to –426 mV (CSE). Based on the test results corrosion may be occurring on the wire mesh in the tested area.

Location No.5: Diversion 10+67 Left Wall

Location No. 5 is shown in Photos No. 5 and 6. The expected #5 reinforcement was not found. A welded wire mesh was exposed and tested at this location. The exposed welded wire mesh was in good condition. A vertical and a horizontal hairline crack were found at the tested area.

The half-cell potential data ranged from –95 to –445 mV (CSE). The most negative potentials were found 2 feet from the bottom of the wall. Corrosion is likely to be occurring on the wire mesh at the bottom of the wall, based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low.

Location No. 6: Diversion 16+17 Right Wall

Test Location No. 6 is shown in Photos No. 7, 8 and 9. The exposed reinforcement was in fair condition. Some brown staining was apparent on several vertical cracks. The concrete was found relatively dry.

The half-cell potential results ranged from 77 to –151 mV (CSE). The most negative potentials and the higher potential differentials were found at the bottom of the wall. Based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion does not appear to be occurring in the tested area. However, the range of potentials was unusually high and the depth of carbonation should be measured to confirm this conclusion.

Location No. 7: Hale 16+00 Bottom Slab

Test Location No. 7 is shown in Photos No. 10 and 11. The concrete and exposed reinforcement were in good condition.

The half-cell potential results ranged from 66 to –134 mV (CSE). The most negative potentials were found near the eastern wall. Based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion does not appear to be occurring in the tested area.

Location No. 8: Permanente 75+00 East Wall

Test Location No. 8 is shown in Photos No. 12 and 13. The exposed reinforcement was not corroding. The concrete was in good condition. No cracking was apparent.

The half-cell potential results ranged from -100 to –342 mV (CSE). The most negative potentials were found 19 inches from the bottom of the wall and on the top edge of the testing area. Based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion had possibly initiated near the bottom of the wall and at the top edge of the tested area.

Location No. 9: Permanente 78+70 East Wall

Test Location No. 9 is shown in Photos No. 14, 15 and 16. The exposed reinforcement was not corroding. The concrete was in good condition. No cracking was apparent.

The half-cell potential results ranged from -225 to –321 mV (CSE). Based on the test results, it is uncertain whether corrosion has initiated in the tested area.

Location No. 10: Permanente 78+70 West Wall

Test Location No. 10 is shown in Photos No. 17, 18 and 19. The exposed reinforcement was not corroding. The concrete was in good condition. No cracking was apparent.

The half-cell potential results ranged from -212 to –415 mV (CSE). Half-cell potentials lower than –400 mV (CSE) were found 38 inches from the bottom of the wall. Based on the test results and the assumptions that concrete carbonation, if any, did not affect the measurements and that the concrete chloride content was low, corrosion may have initiated in some of the test area.

TABLES

TABLE 1: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 1: HALE 5+00 LEFT WALL

Date: 10/7/99
Inspector: LS/MT

Observations: Cracks No delamination rust bleeding on bottom
Concrete cover Bottom: 2.5 inches
Top: 3 inches

Resistance of rebar in tested area:
Nillson meter 8.5 ohm
Voltmeter 0.25 mV 7.2 ohm

Test spacing Horizontal 10 inches
Vertical 6 inches
Reference electrode: Copper-copper sulfate

	Col 1	**Col 2**	**Col 3**	**Col 4**	**Col 5**	**Col 6**	**Col 7**	**Col 8**	**Col 9**	**Col 10**	**Col 11**
Row 1	-204	-217	-298	-262	-235	-183	-247	-245	-151	-220	-215
Row 2	-206	-249	-282	-288	-203	-180	-141	-128	-161	-163	-190
Row 3	-194	-236	-278	-297	-201	-173	-145	-167	-152	-172	-235
Row 4	-179	-207	-223	-225	-139	-174	-148	-162	-142	-146	-236
Row 5	-160	-237	-186	-213	-237	-232	-224	-237	-181	-149	-245
Row 6	-176	-189	-143	-156	-185	-218	-182	-194	-226	-152	-202
Row 7	-182	-253	-271	-285	-229	-187	-188	-208	-214	-242	-253
Row 8	-253	-264	-264	-227	-259	-252	-261	-295	-299	-288	-263

Maximum: *-128* mV
Minimum: *-299* mV
Average: *-210.3* mV
Standard Deviation: *46.5* mV
Max. Diff. Consecutive Points: *129* mV

Number - Shaded areas designate locations of exposed rebar

TABLE 2: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 2: HALE 1+52 RIGHT WALL

Date: 10/7/99
Inspector: LS/MT

Observations: No cracking - no delamination

Concrete cover	Bottom:	3.25 inches
	Top:	3 inches
Exposed rebar:	Bottom:	no corrosion
	Top:	no corrosion

Resistance of rebar in tested area:

Nillson meter	0.083 ohm	
Voltmeter	0 mV	0.35 ohm
Test spacing	Horizontal	16 inches
	Vertical	6 inches
Reference electrode:		Copper-copper sulfate

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
Row 1	-75	-111	-147	-107	-151	-207	-152	-147	-213
Row 2	-174	-188	-190	-150	-211	-208	-177	-196	-214
Row 3	-135	-187	-175	-131	-164	-163	-174	-176	-165
Row 4	-158	-201	-187	-128	-147	-149	-174	-195	-116
Row 5	-164	-113	-153	-97	-61	-88	-109	-108	-85
Row 6	-161	-167	-140	-136	-129	-134	-129	-172	-186

[illegible]ximum:	*-61*
Minimum:	*-214*
Average:	*-153.2*
Standard Deviation:	*37.2*
Max. Diff. Consecutive Points:	*186*

Number - Shaded areas designate locations of exposed rebar

TABLE 3: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 3: HALE 9+15 LEFT WALL

Date: 10/7/99
Inspector: LS/MT

Observations: Spalled concrete on top left corner of test area
Concrete cover Bottom: 3 inches
Top: 2 inches
Exposed rebar: Bottom: not corroding
Top: corroding
Resistance of rebar in tested area:
Nillson meter 7.5 ohm
Voltmeter 0.04 mV 8.22 ohm

Test spacing Horizontal 16 inches
Vertical 6 inches

Reference electrode: Copper-copper sulfate

half-cell potential mapping: (mV)

Table 1. Raw Data - Potentials Survey Point-to-Point

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
Row 1	-268	-277	-235	-236	-175	-158	-160	-249	-319	-303
Row 2	-168	-193	-301	-300	-311	-340	-290	-340	-239	-208
Row 3	-183	-213	-304	-310	-345	-323	-356	-280	-280	-277
Row 4	-208	-314	-375	-371	-354	-350	-332	-317	-274	-248
Row 5	-207	-279	-293	-293	-292	-263	-258	-245	-236	-244

Maximum:	*-158*
Minimum:	*-375*
Average:	*-273.9*
Standard Deviation:	*57.0*
Max. Diff. Consecutive Points:	*182*

Number - Shaded areas designate locations of exposed rebar

TABLE 4: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 4: DIVERSION 3+79 LEFT WALL

Date: 10/7/99
Inspector: LS/MT

Observations: Thin cracks - no rebar but welded wire mesh
Concrete cover Bottom: 2.5 inches
Top: 4 inches
Exposed rebar: Bottom: not corroding
Top: not corroding
Resistance of rebar in tested area:
Nillson meter 0.07 ohm
Voltmeter 0 mV 0.07 ohm

Test spacing Horizontal 12 inches
Vertical 12 inches
Reference electrode: Copper-copper sulfate

	Col 1	**Col 2**	**Col 3**	**Col 4**	**Col 5**	**Col 6**	**Col 7**	**Col 8**
Row 1	-365	-394	-400	-393	-392	-383	-356	-350
Row 2	-402	-397	-412	-399	-339	-362	-349	-356
Row 3	-395	-381	-402	-400	-406	-360	-378	-398
Row 4	-389	-377	-400	-418	-419	-400	-388	-349
Row 5	-389	-426	-418	-405	-408	-406	-396	-413
Row 6	-358	-373	-341	-332	-348	-322	-301	-330
Row 7	-321	-318	-310	-305	-304	-300	-310	-310

Maximum: *-300*
Minimum: *-426*
Average: *-370.6*
Standard Deviation: *36.96*
Max. Diff. Consecutive Points: *55*

Number - Shaded areas designate locations of exposed rebar

TABLE 5: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 5: DIVERSION 10+67 LEFT WALL

Date: 10/7/99
Inspector: LS/MT

Observations:
Concrete cover Bottom: 2.5 inches
Top: 2 inches
Exposed rebar: Bottom: not corroding
Top: not corroding
Resistance of rebar in tested area:
Nillson meter 0.4 ohm
Voltmeter 0.34 mV 2.24 ohm

Test spacing Horizontal 12 inches
Vertical 12 inches
Reference electrode: Copper-copper sulfate

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
Row 1	-141	-169	-142	-133	-113	-109	-95
Row 2	-175	-194	-237	-160	-162	-162	-199
Row 3	-227	-234	-284	-214	-200	-106	-148
Row 4	-212	-211	-214	-224	-199	-216	-138
Row 5	-249	-267	-263	-234	-220	-218	-192
Row 6	-240	-285	-204	-280	-267	-279	-211
Row 7	-331	-311	-326	-355	-309	-314	-315
Row 8	-445	-240	-236	-243	-244	-235	-241

Maximum:	*-95*
Minimum:	*-445*
Average:	*-222.2*
Standard Deviation:	*69.5*
Max. Diff. Consecutive Points:	*205*

Number - Shaded areas designate locations of exposed rebar

TABLE 6: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 6 DIVERSION 16+17 RIGHT WALL

Date: 10/8/99
Inspector: LS/MT

Observations: Vertical and horizontal cracks - some mechanical concrete damage
Concrete cover Bottom: 2.5 inches
Top: 2.5 inches
Exposed rebar: Bottom: fair condition
Top: fair condition
Resistance of rebar in tested area:
Nillson meter 0.25 ohm
Voltmeter 0.01 mV 1.51 ohm

Test spacing Horizontal 17 inches
Vertical 12 inches

Reference electrode: Copper-copper sulfate

	Col 1	**Col 2**	**Col 3**	**Col 4**	**Col 5**	**Col 6**	**Col 7**
Row 1	72	44	52	69	77	44	11
Row 2	54	-8	-2	27	-34	-21	-7
Row 3	37	-2	2	29	43	1	-12
Row 4	14	-21	-59	-46	-18	4	-64
Row 5	-77	-101	-151	-116	-86	-136	-107

Maximum: *77*
Minimum: *-151*
Average: *-13.9*
Standard Deviation: *60.8*
Max. Diff. Consecutive Points: *73*

Number - Shaded areas designate locations of exposed rebar

TABLE 7: HALF CELL POTENTIAL DATA (mV)
LOCATION No. 7 HALE 16+00 BOTTOM SLAB

Date: 10/8/99
Inspector: LS/MT

Observations:
Concrete cover North 4.25 inches
South 4 inches
Exposed rebar: Bottom: good condition
Top: good condition
Resistance of rebar in tested area:
Nillson meter 0.053 ohm
Voltmeter 0 mV 0.95 ohm

Test spacing Horizontal 12 inches
Vertical 12 inches

Reference electrode: Copper-copper sulfate

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Row 1	-120	-129	-72	-17	-17	-14	-17	66
Row 2	-118	-126	-74	-22	-11	-3	-3	44
Row 3	-123	-74	-65	-36	-7	-11	-39	15
Row 4	-117	-101	-44	-45	-14	-15	-31	11
Row 5	-101	-75	-33	-16	-15	-16	-11	13
Row 6	-130	-81	-52	5	-10	-5	-21	5
Row 7	-134	-96	-73	-10	-6	-20	-15	6

Maximum:	*66*
Minimum:	*-134*
Average:	*-39.6*
Standard Deviation:	*48.0*
Max. Diff. Consecutive Points:	*83*

Number - Shaded areas designate locations of exposed rebar

TABLE 8: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 8 PERMANENTE 75+00 EAST WALL

Date: 10/8/99
Inspector: LS/MT

Observations:
Concrete cover Bottom: 1 inches
Top: 2.25 inches
Exposed rebar: Bottom: not corroding
Top: not corroding
Resistance of rebar in tested area:
Nillson meter 3.5 ohm
Voltmeter 0.06 mV 4.9 ohm

Test spacing Horizontal 12 inches
Vertical 12 inches

Reference electrode: Copper-copper sulfate

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
Row 1	-342	-288	-316	-330	-224	-195
Row 2	-228	-183	-180	-159	-229	-252
Row 3	-153	-122	-179	-130	-100	-111
Row 4	-182	-189	-221	-213	-181	-152
Row 5	-240	-240	-335	-318	-262	-200
Row 6	-263	-248	-278	-263	-259	-303

Maximum: *-100*
Minimum: *-342*
Average: *-224.1*
Standard Deviation: *65.4*
Max. Diff. Consecutive Points: *73.5*

Number - Shaded areas designate locations of exposed rebar

ABLE 9: HALF CELL POTENTIAL DATA (mV)
LOCATION No. 9 PERMANENTE 78+70 EAST WALL

Date: 10/8/99
Inspector: LS/MT

Observations: Crack
Concrete cover Top: 1 inches
Bottom: 2.25 inches
Exposed rebar: Bottom: no corrosion
Top: no corrosion
Resistance of rebar in tested area:
Nillson meter 0.018 ohm
Voltmeter 0.03 mV 0.4 ohm

Test spacing Horizontal 12 inches
Vertical 14 inches

Reference electrode: Copper-copper sulfate

	Col 1	**Col 2**	**Col 3**	**Col 4**
Row 1	-241	-265	-304	-231
Row 2	-236	-321	-264	-253
Row 3	-236	-320	-266	-228
Row 4	-292	-296	-276	-311
Row 5	-229	-268	-277	-311
Row 6	-230	-229	-225	-261

Maximum:	*-225*
Minimum:	*-321*
Average:	*-265.4*
Standard Deviation:	*32.5*
Max. Diff. Consecutive Points:	*85*

Number - Shaded areas designate locations of exposed rebar

TABLE 10: HALF CELL POTENTIAL DATA (mV)

LOCATION No. 10 PERMANENTE 78+70 WEST WALL

Date:	10/8/99		
Inspector:	LS/MT		
Observations:	Good concrete no crack		
Concrete cover	Top:	2 inches	
	Bottom:	2.75 inches	
Exposed rebar:	Bottom:	not corroding	
	Top:	not corroding	
Resistance of rebar in tested area:			
Nillson meter		0.035 ohm	
Voltmeter		0.07 mV	0.33 ohm
Test spacing	Horizontal	12 inches	
	Vertical	12 inches	
Reference electrode:		Copper-copper sulfate	

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
Row 1	-270	-295	-333	-216	-279	-310	-294
Row 2	-369	-364	-285	-316	-302	-312	-295
Row 3	-373	-400	-289	-288	-384	-383	-304
Row 4	-351	-404	-368	-301	-323	-305	-300
Row 5	-389	-415	-383	-362	-397	-404	-267
Row 6	-344	-412	-403	-289	-397	-398	-279
Row 7	-212	-215	-231	-225	-305	-333	-267

Maximum:	*-212*
Minimum:	*-415*
Average:	*-323.0*
Standard Deviation:	*58.0*
Max. Diff. Consecutive Points:	*279*

Number - Shaded areas designate locations of exposed rebar

FIGURES

FIGURE 1
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 1: HALE 5+00 LEFT WALL

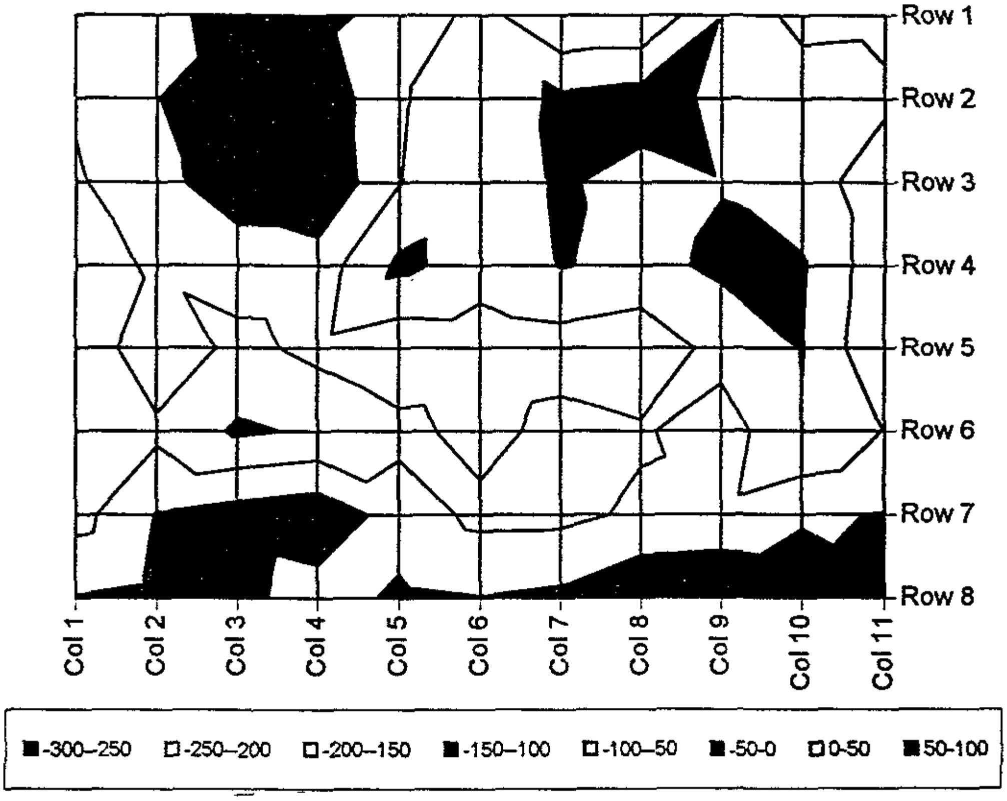


FIGURE 2
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 2: HALE 1+52 RIGHT WALL

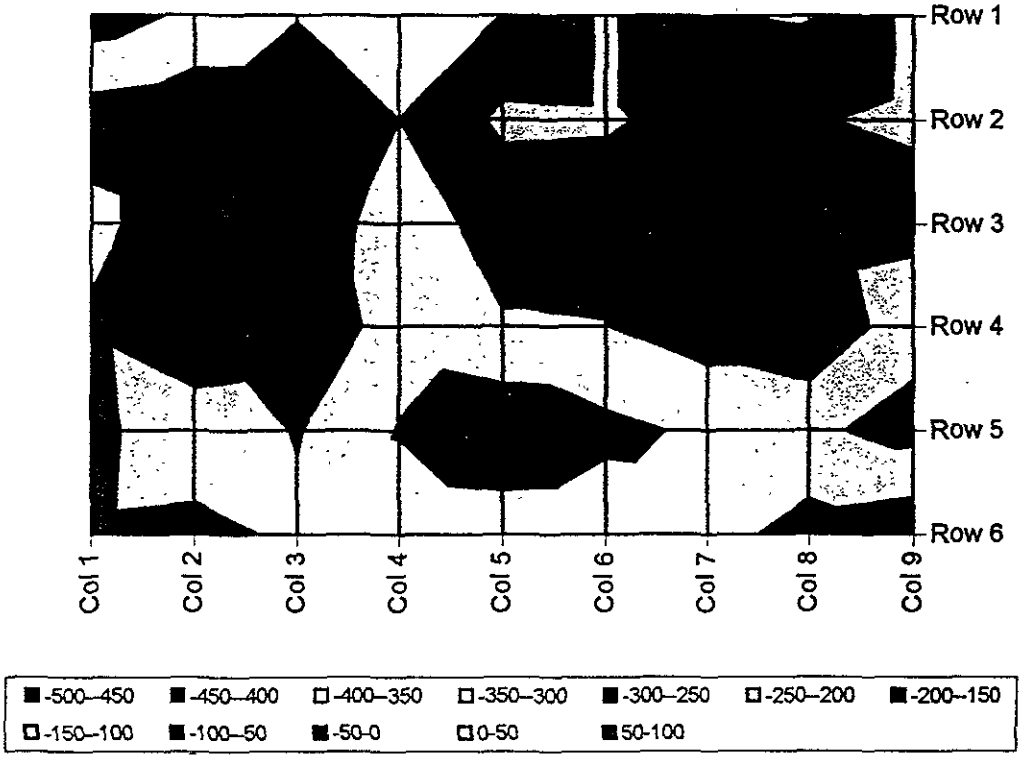


FIGURE 3
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 3: HALE 9+15 LEFT WALL

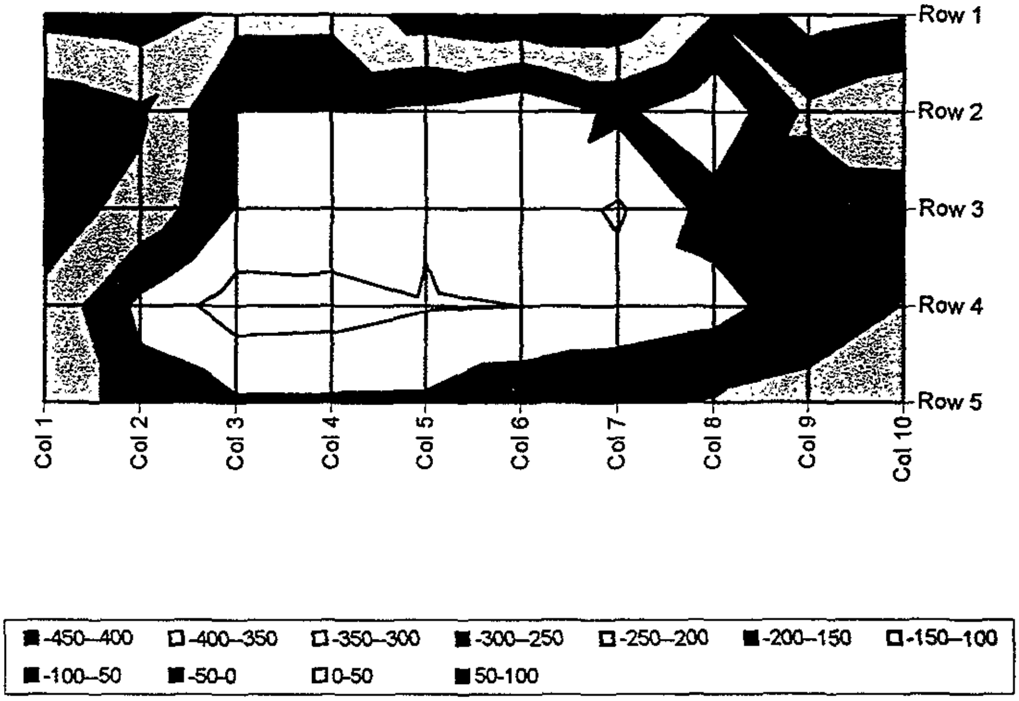


FIGURE 4
Helf-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 4: DIVERSION 3+79 LEFT WALL

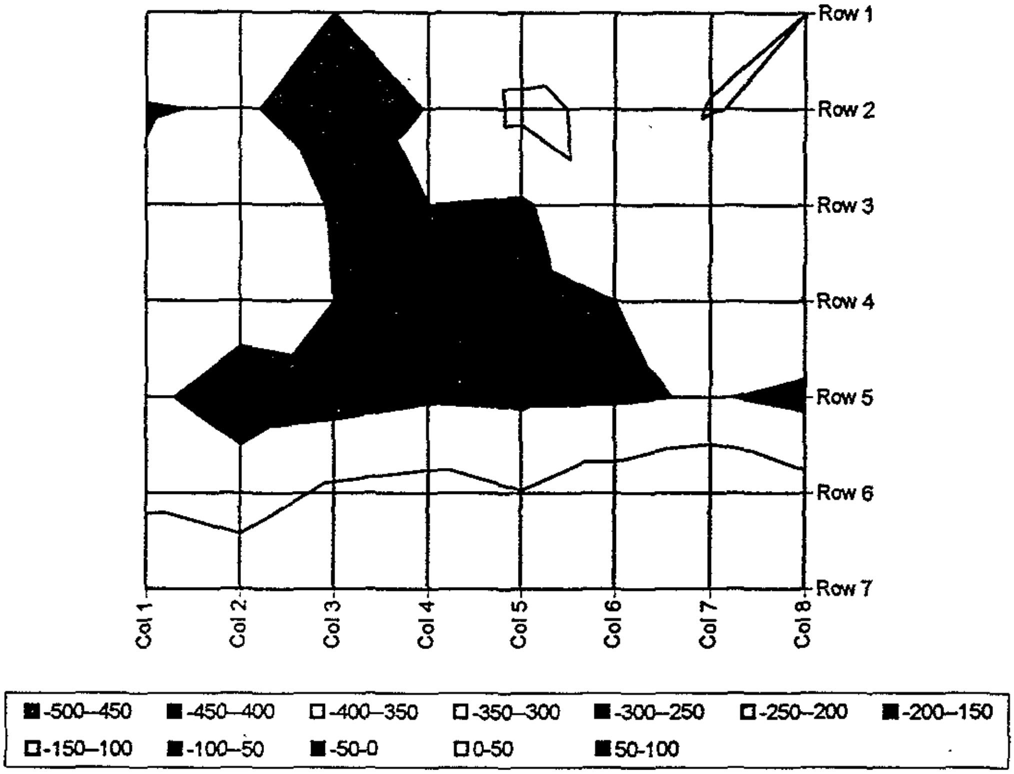


FIGURE 5
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
LocationNo. 5: DIVERSION 10+67 LEFT WALL

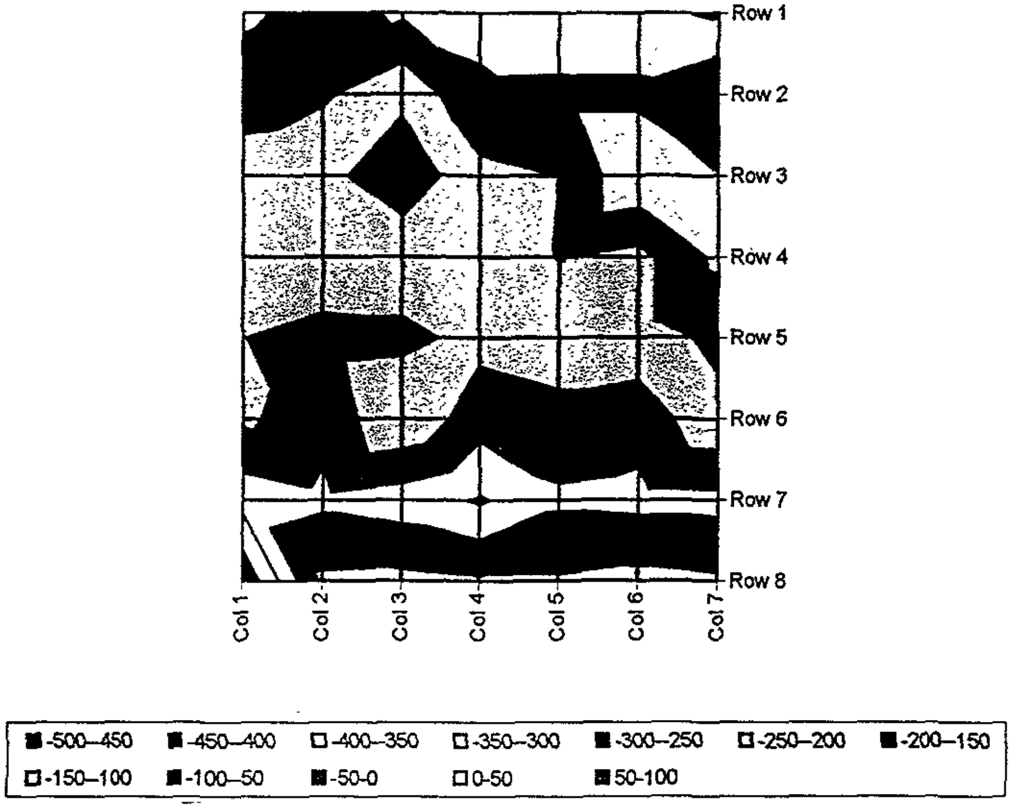


FIGURE 6
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 6 DIVERSION 16+17 RIGHT WALL

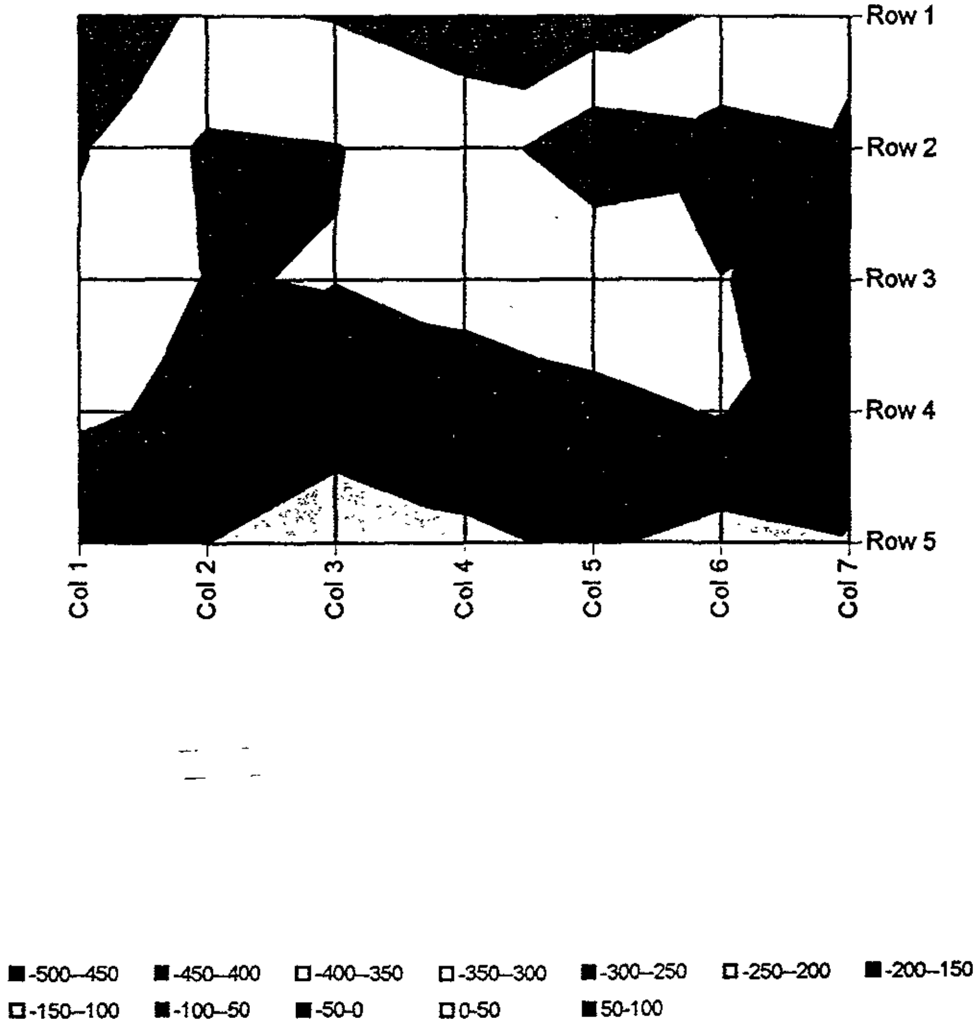


FIGURE 7
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 7 HALE 16+00 BOTTOM SLAB

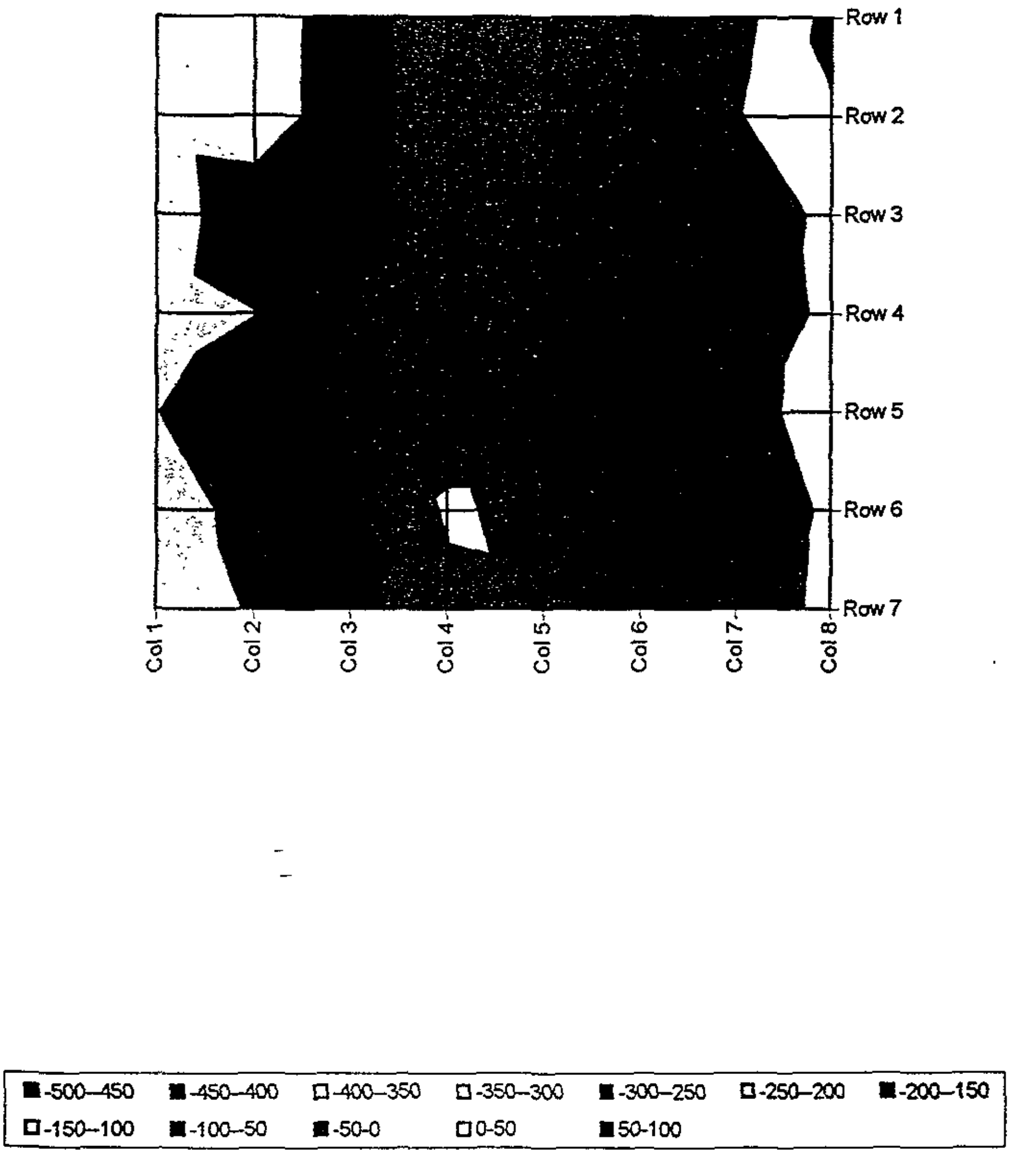


FIGURE 8
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 8 PERMANENTE 75+00 EAST WALL

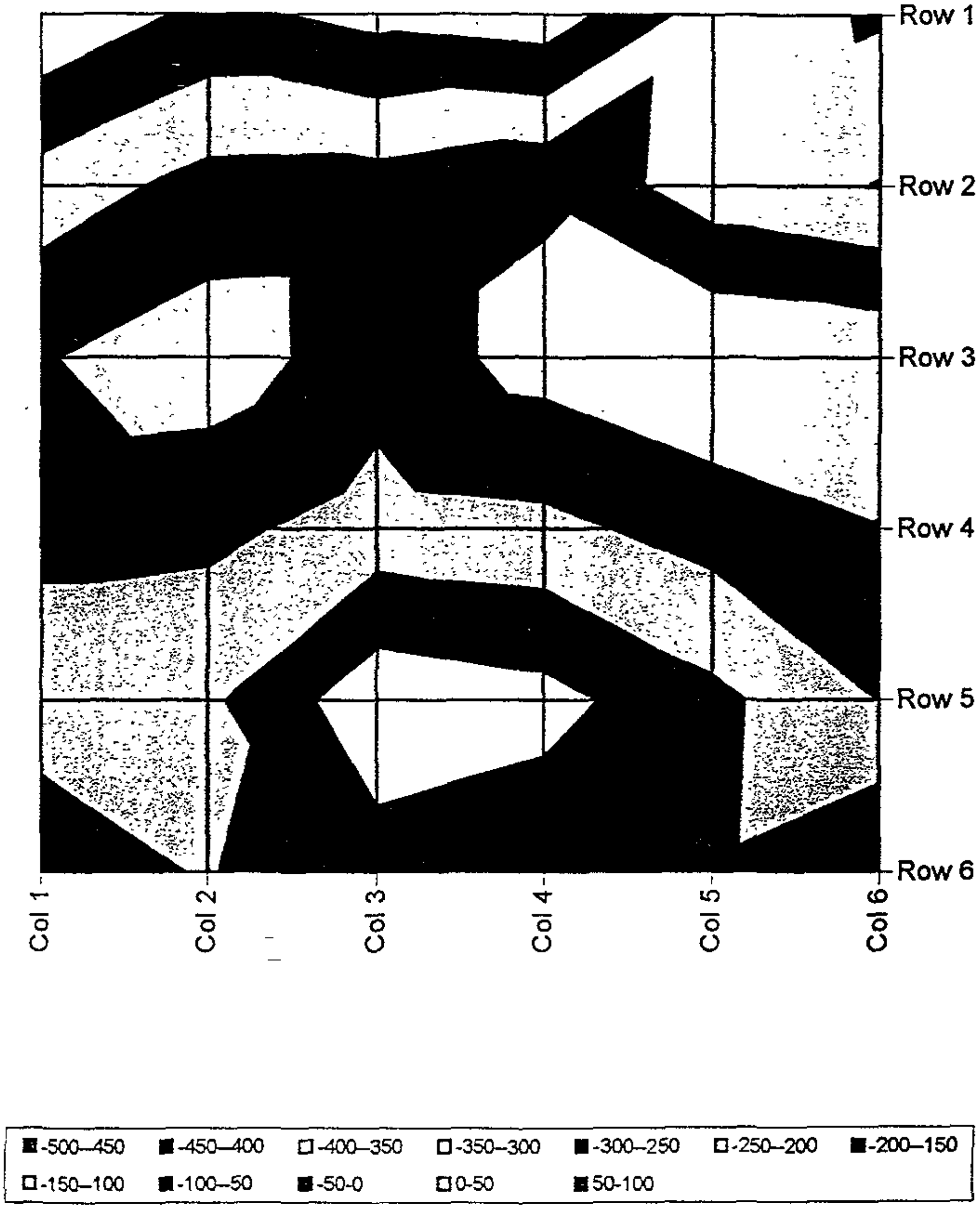


FIGURE 9
Half-Cell Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 9 PERMANENTE 78+70 EAST WALL

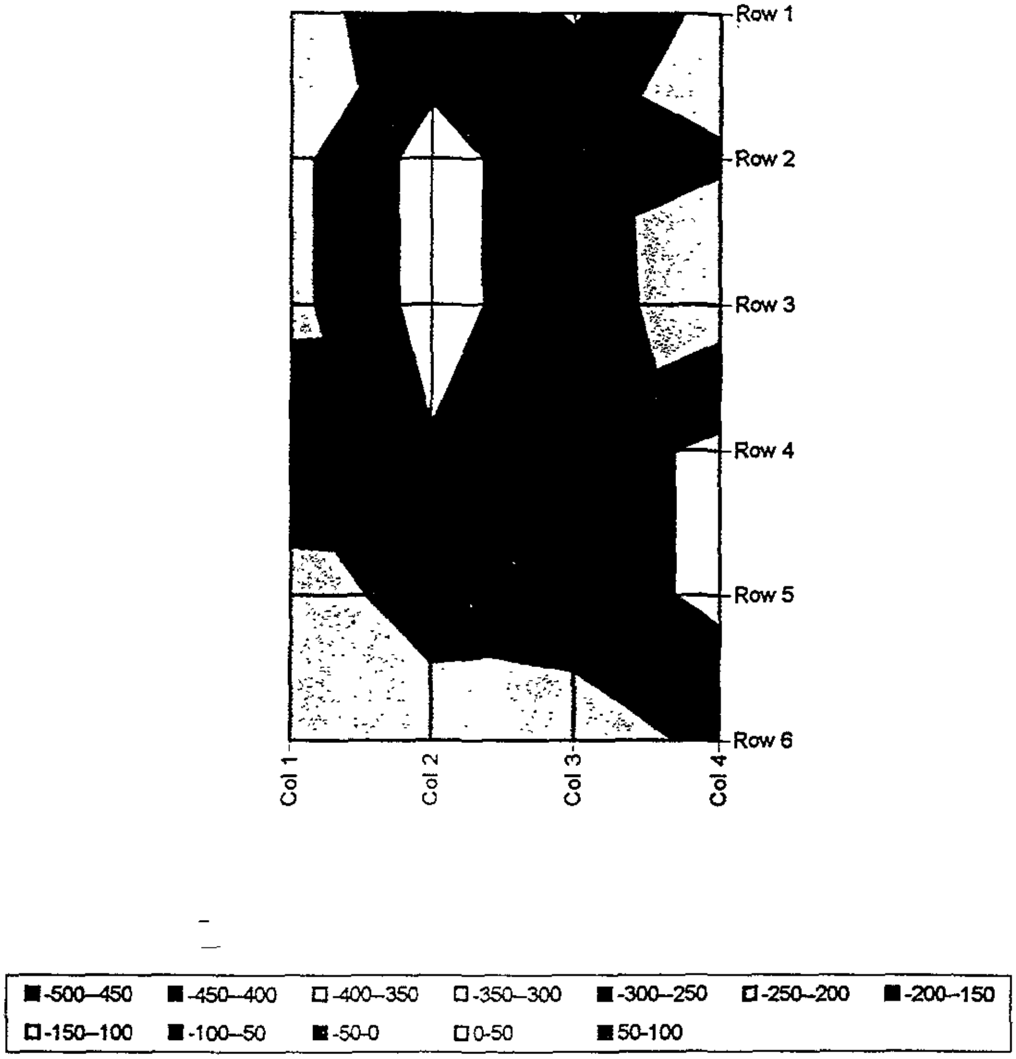


FIGURE 10
Half- Potential Survey Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No10. PERMANENTE 78+70 WEST WALL

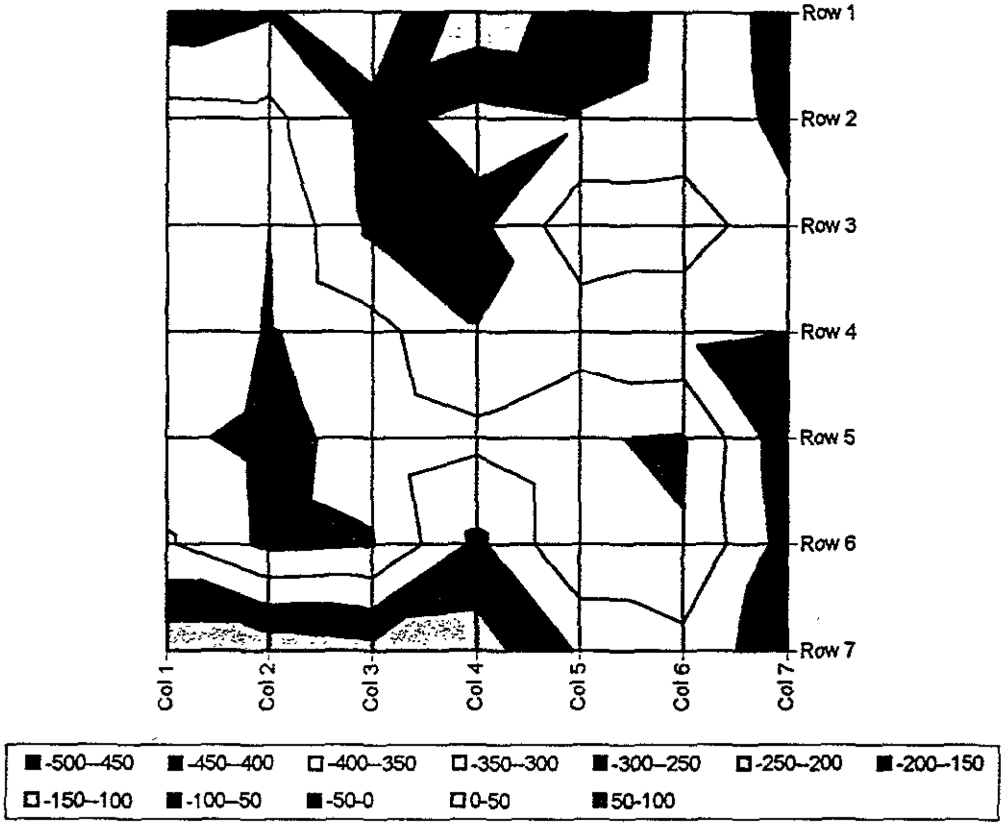


FIGURE 11

Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 1: HALE 5+00 LEFT WALL

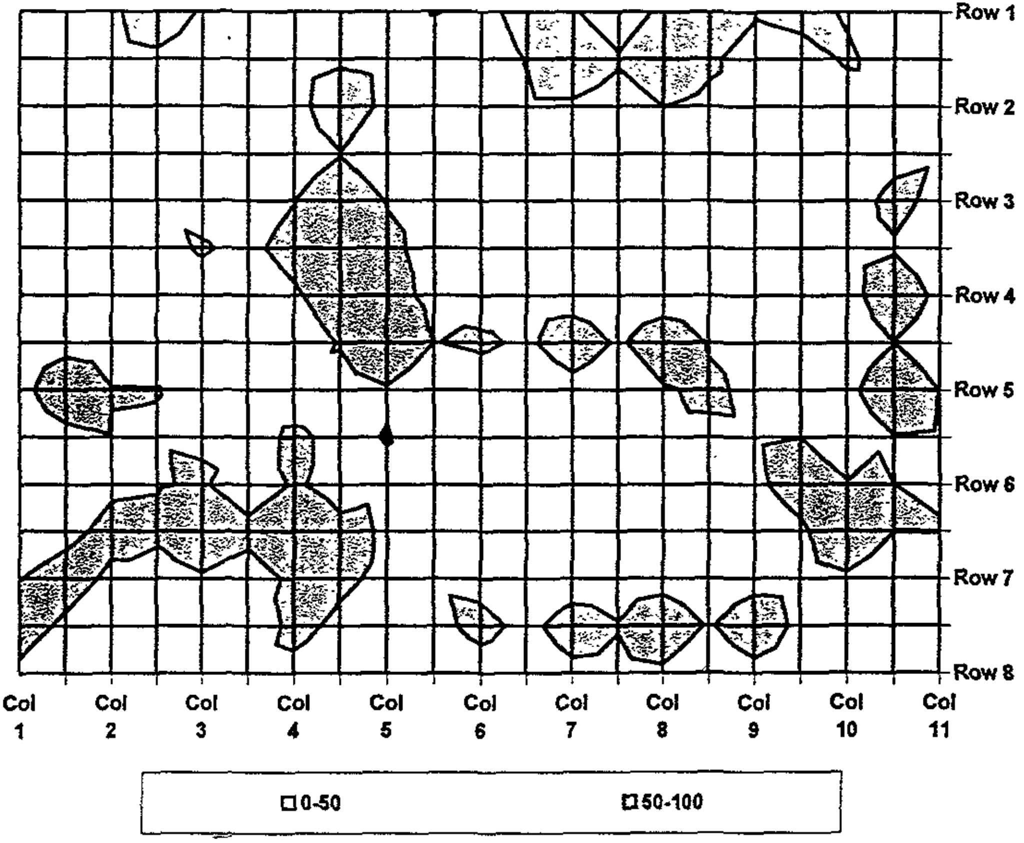


FIGURE 12
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Locaton No. 2: HALE 1+52 RIGHT WALL

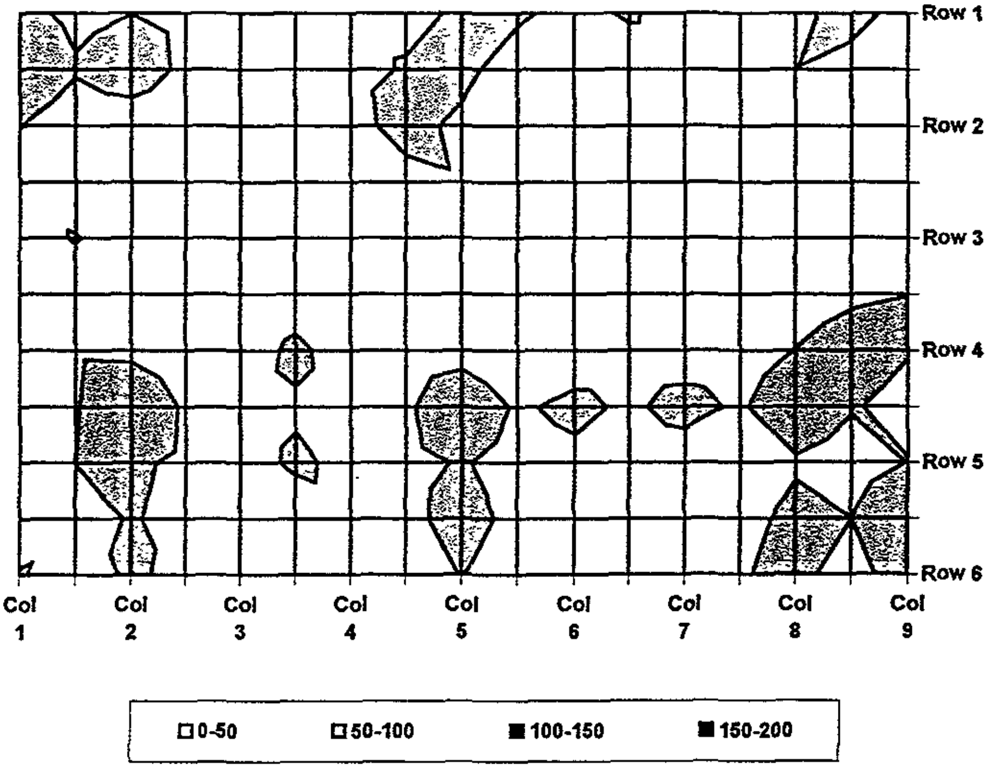


FIGURE 13
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 3: HALE 9+15 LEFT WALL

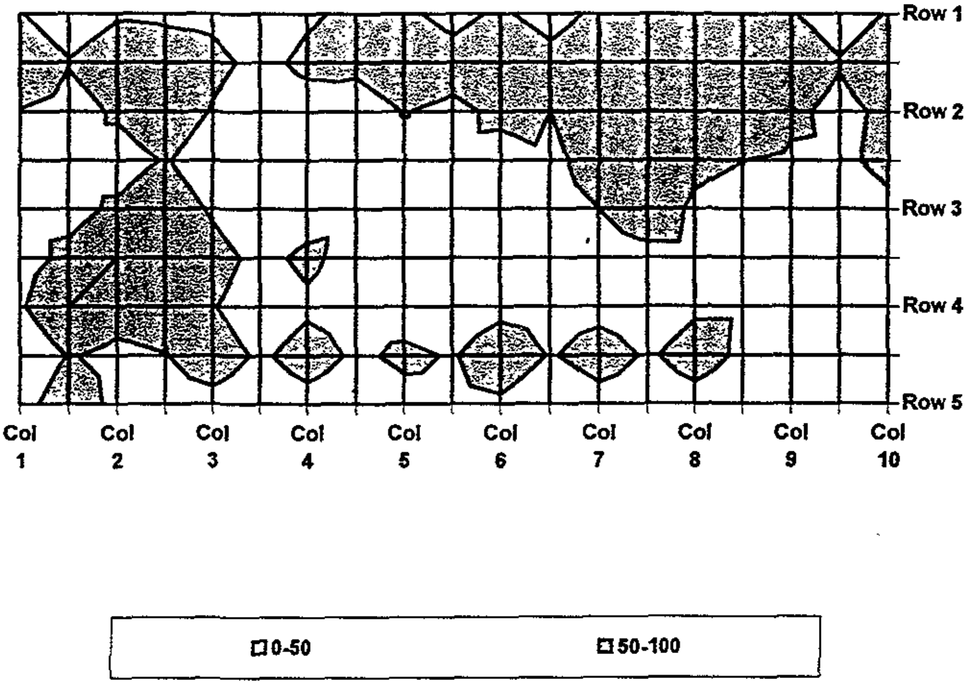


FIGURE 14
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 4: DIVERSION 3+79 LEFT WALL

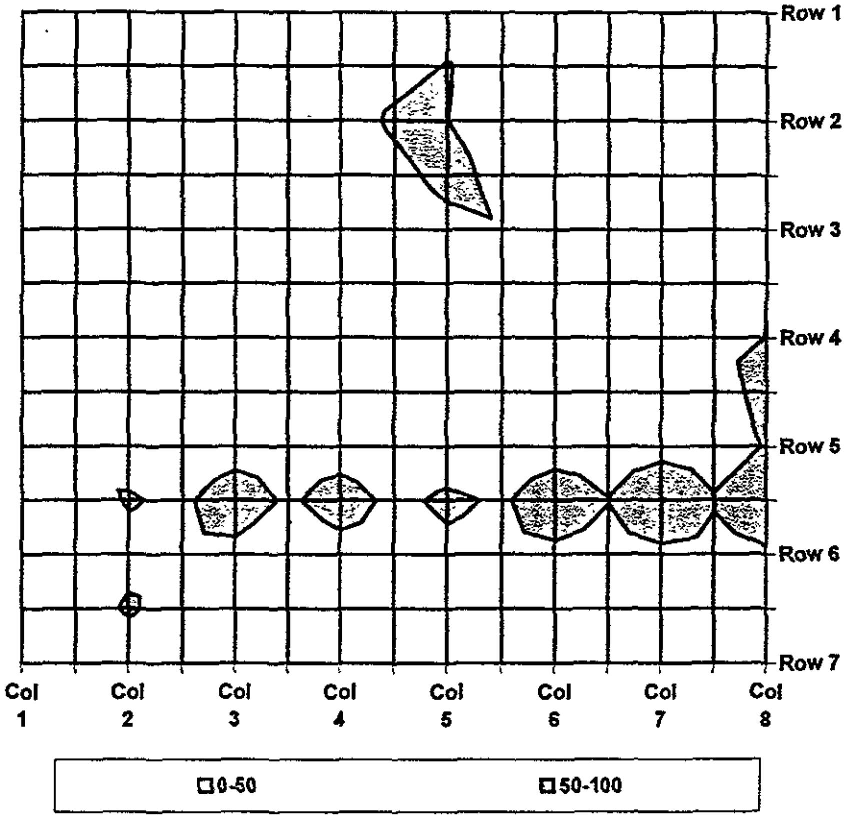


FIGURE 15
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
LocationNo. 5: DIVERSION 10+67 LEFT WALL

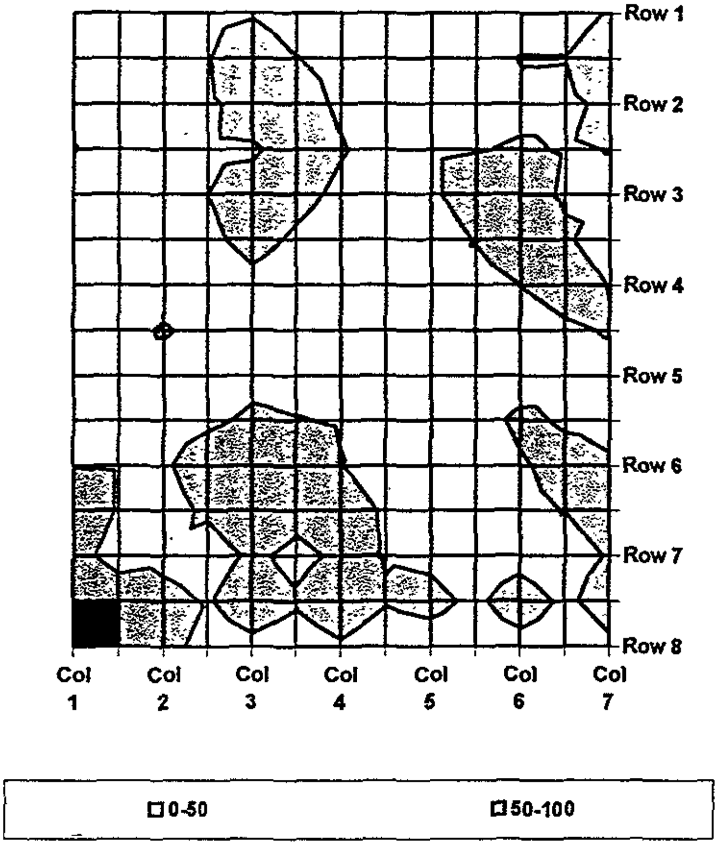


FIGURE 16
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 6 DIVERSION 16+17 RIGHT WALL

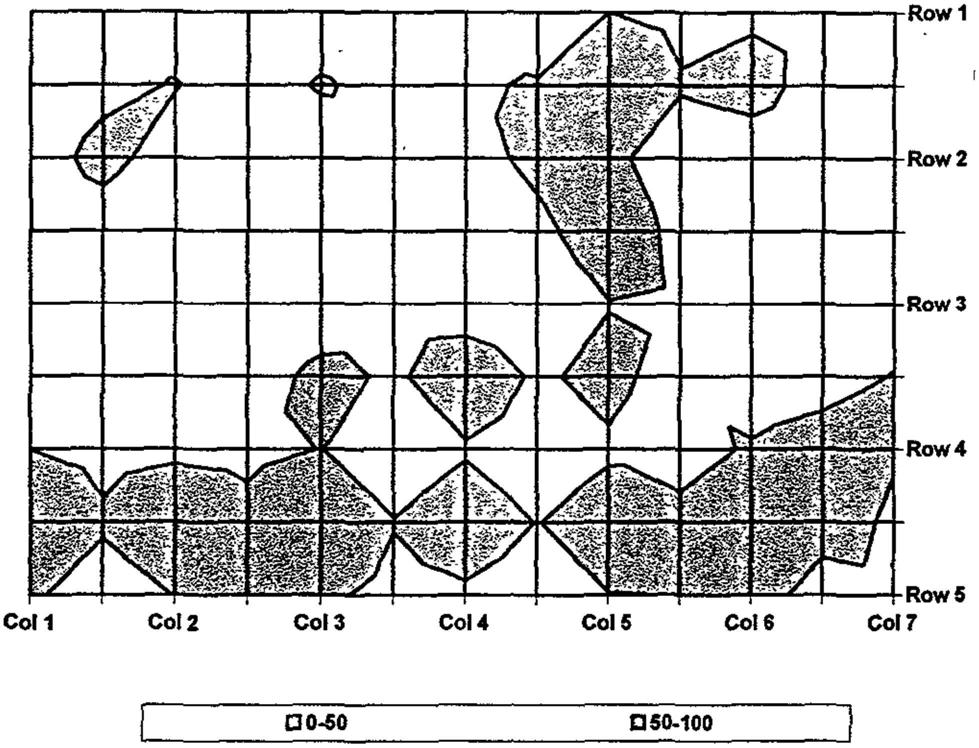


FIGURE 17
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 7 HALE 16+00 BOTTOM SLAB

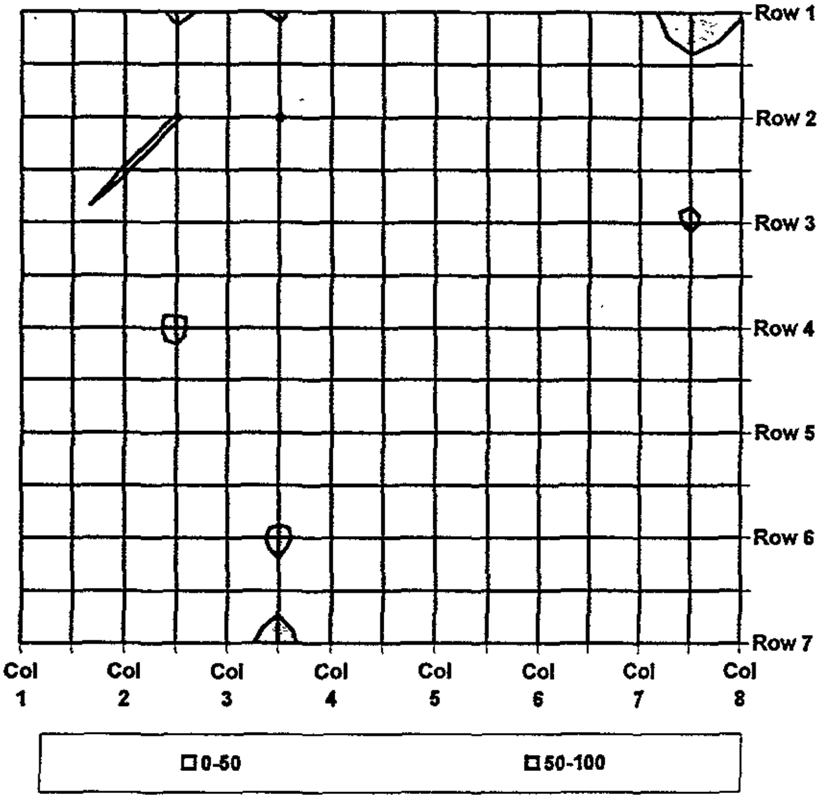


FIGURE 18
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 8 PERMANENTE 75+00 EAST WALL

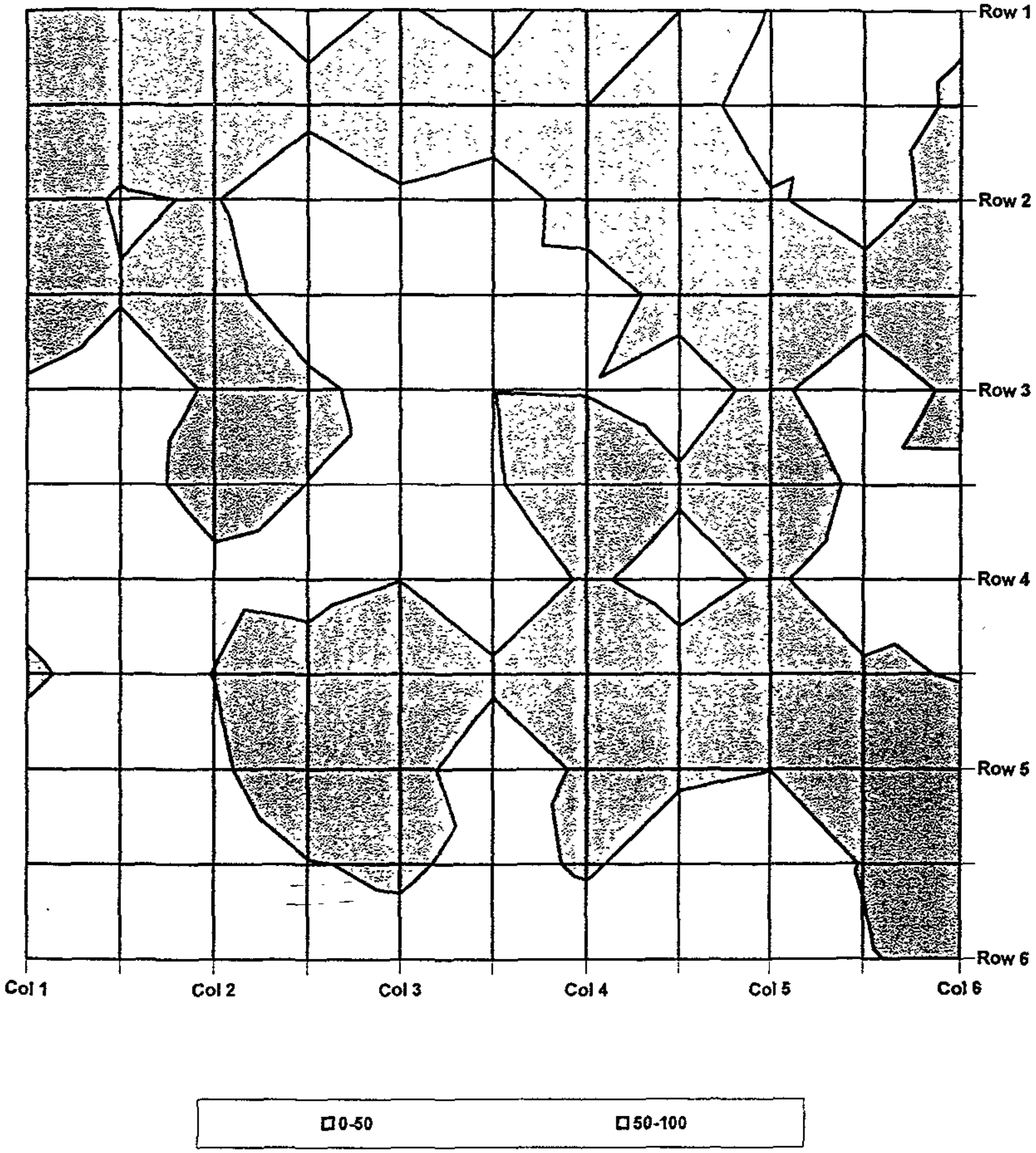
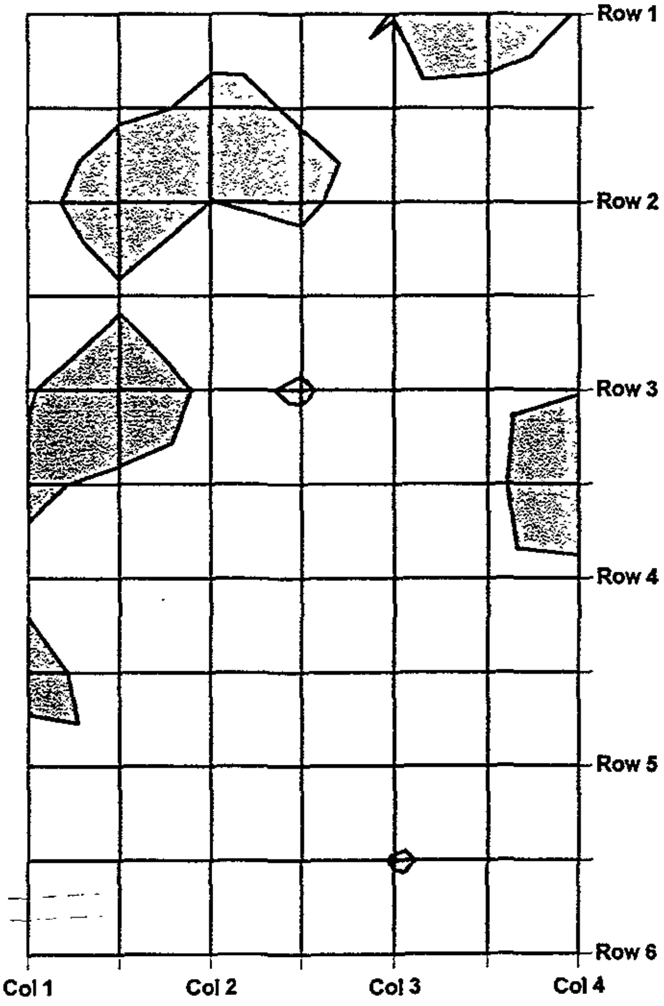


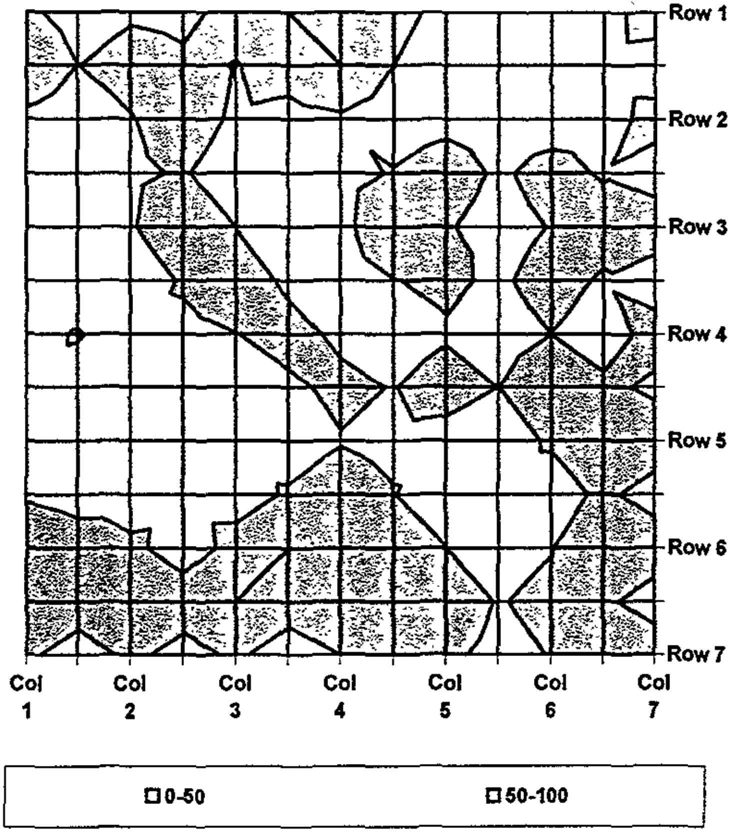
FIGURE 19
Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No. 9 PERMANENTE 78+70 EAST WALL

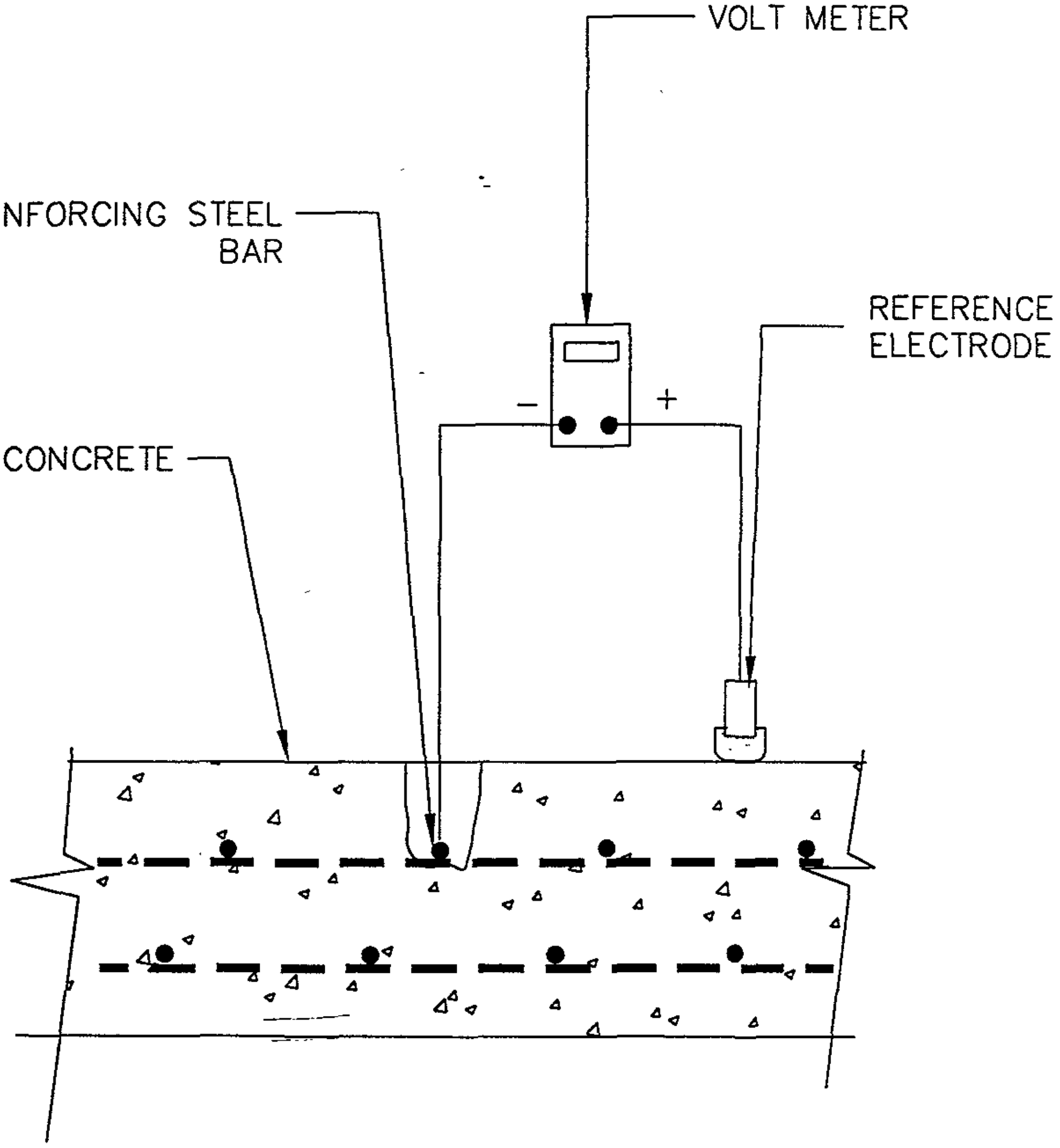


☐ 0-50	▨ 50-100

FIGURE 20

Potential Differential Contour Map
(Millivolts Versus Copper-copper sulfate)
Location No 10. PERMANENTE 78+70 WEST WALL





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Oakland, California 94612

HALF CELL POTENTIAL MEASUREMENT

JOB No. 9940

FIGURE 21

PHOTOS

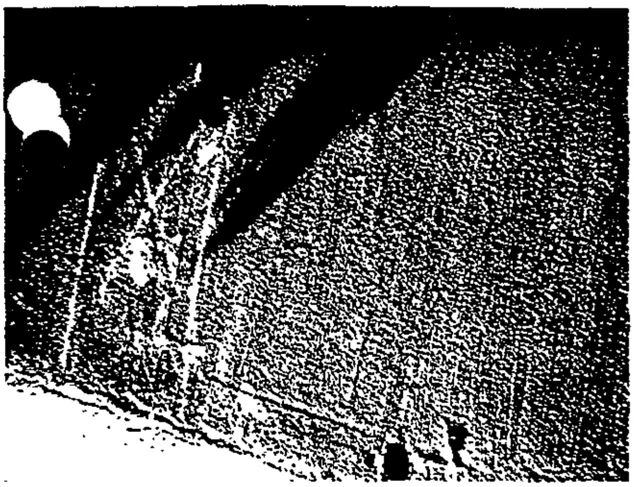

Photo No. 1
Hale 9+15 Left Wall

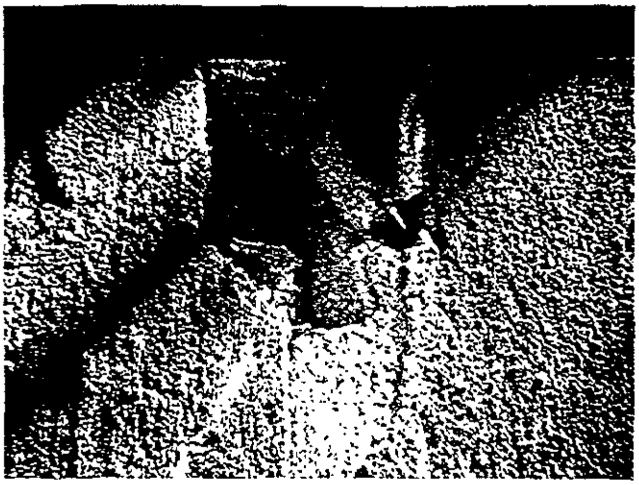

Photo No. 2
Hale 9+15 Left Wall
Top Corner

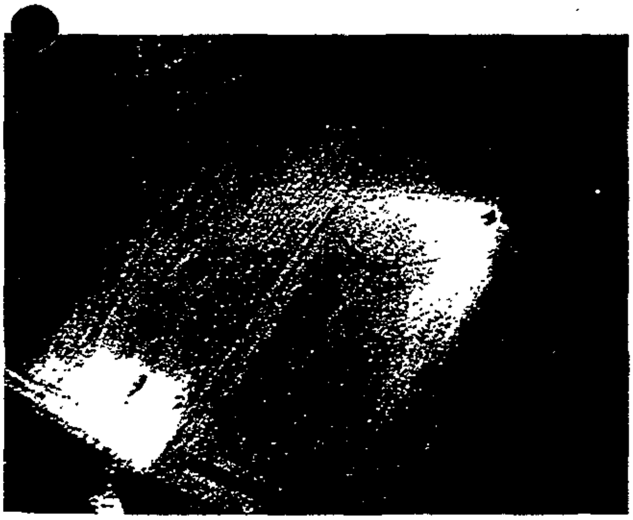

Photo No. 3
Diversion 3+79 Left Wall

Photo No. 4
Diversion 3+79 Left Wall
Bottom Left Corner

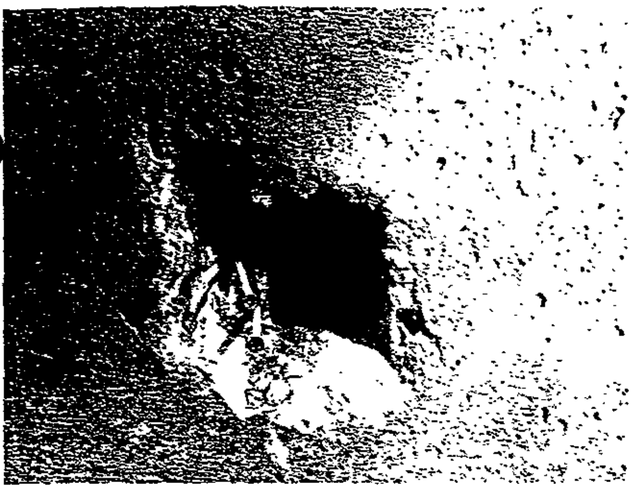

Photo No. 9
Diversion 16+17 Right Wall
Bottom Left Corner

Photo No. 10
Hale 16+00 Bottom Slab

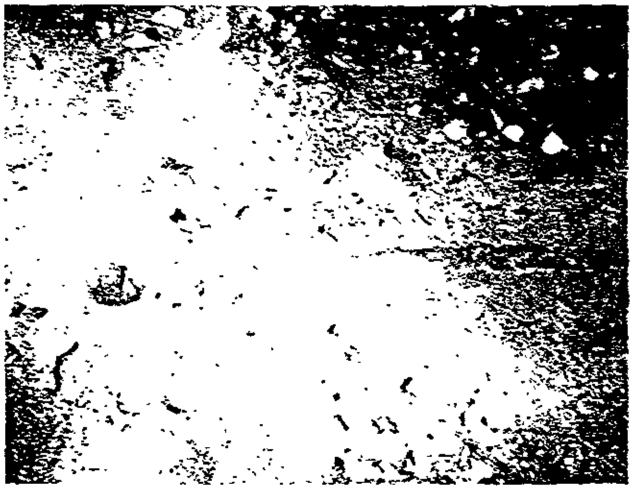

Photo No. 11
Hale 16+00 Bottom Slab
Exposed Reinforcement

Photo No. 12
Permanente 75+00 East Wall

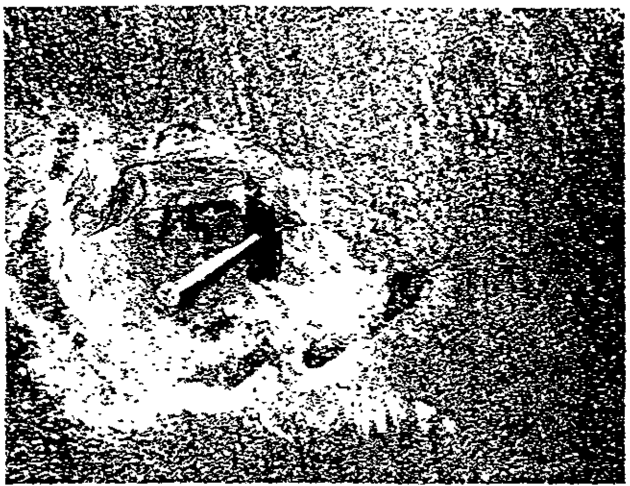

Photo No. 13
Permanente 75+00 East Wall
Bottom Right Corner

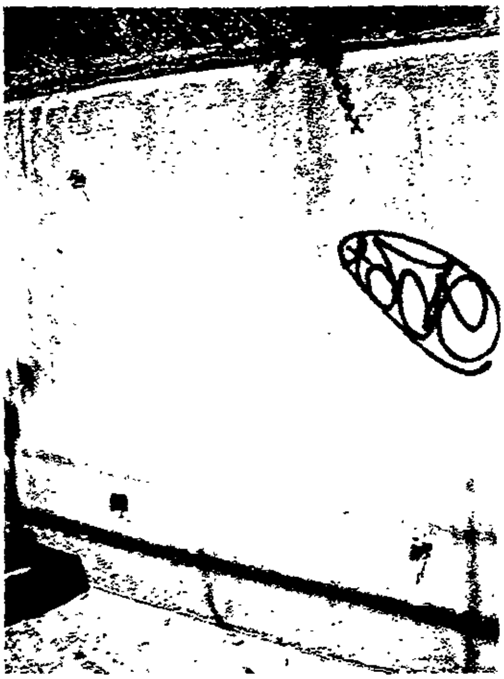

Photo No. 14
Permanente 78+70 East Wall

Photo No. 15
Permanente 78+70 East Wall
Bottom Corner

Photo No. 16
Permanente 78+70 East Wall
Top Corner

Photo No. 17
Permanente 78+70 West Wall

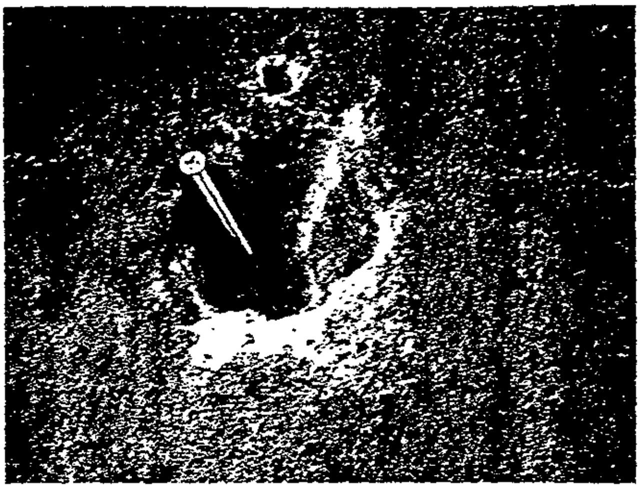

Photo No. 18
Permanente 78+70 West Wall
Top Corner

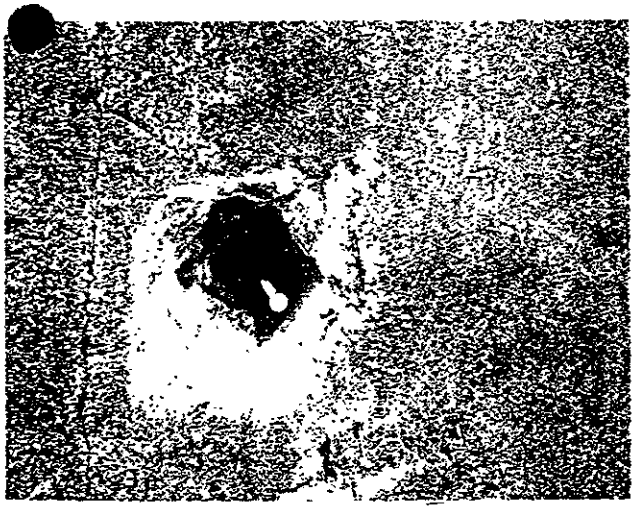

Photo No. 19
Permanente 78+70 West Wall
Bottom Corner

PERMANENTE CREEK SURVEY SHEET

CORE # DIA ( )	STA IN METRIC	CORE'S LENGTH	CORE'S DIST TO SLAB	BARS SIZE												TEST HAMMER		SAMPLER COLLECTED	REMARKS
				LT. WALL						RT. WALL									
				VERT.	COVER	SPACING	HORZ.	COVER	SPACING	VERT.	COVER	SPACING	HORZ.	COVER	SPACING	LT	RT		
A1 (2.5")	40+06.10 LT	7"	38"	#5	1.75"	10"	#5	2"	8"	#5	2"	14"	#5	2.25"	14"	60/58	59/60	YES	CULVERT WALL @ HWY 101 BEGINNING STA 40+00 METRIC
A2 (2.5")	43+04.80 RT	8.5"	–	#5	1.75"	12"	#7	2"	12"	#7	1.75"	12"	#5	1.50"	12"	57/53	55/57	YES	
A3 (2.5")	46+09.60 LT	8.5"	–	#5	1.75"	12"	#5	2"	11"	#5	1.25"	12"	#5	1.50"	11"	57/56	59/61	YES	
A4 (2.5")	47+86 RT	7.75"	35"	#5	1.5"	18"	#5	2"	18"	#7	2"	18"	#5	2"	16"	52/54	57/55	NO	ADDITIONAL CORING REQUESTED BY BCA.
A5 (2.5")	49+14.40 RT	8.75"	44"	#5	1.50"	14"	#5	1.75"	12"	#7	2"	12"	#5	2.0"	14"	58/59	59/57	YES	
A6 (2.5")	51+10 RT	9.5"	42"	#5	2.0"	18"	#5	2.25"	18"	#7	2.0"	18"	#5	2.0"	16"	54/54	56/54	NO	ADDITIONAL CORING REQUESTED BY BCA.
A7 (2.5")	52+19.20 LT	8.5"	34"	#5	1.0"	10"	#5	1.75"	12"	#5	1.5"	12"	#7	2.25"	12"	56/58	58/54	YES	
A8 (4.0")	55+24 RT	10.5"	36"	#5	2.0"	9"	#5	2.25"	12"	#5	2.5"	14"	#5	3.0"	16"	56/58	54/56	YES	
A9 (2.5")	73+25.80 LT	8"	21"	#5	2.5"	20"	#5	3.0"	16"	#7	2.25"	20"	#5	2.25"	16"	48/54	56/60	YES	
A10 (2.5")	75+00 RT	8"	20"	–	–	–	–	–	–	#7	1.75"	18"	#7	2.0"	18"	48/50	–	YES	ADDITIONAL CORING REQUESTED BY BCA.
A11 (2.5")	75+00 LT	8"	19"	#7	1.75"	20"	#5	1.75"	18"	–	–	–	–	–	–	–	60/58	YES	ADDITIONAL CORING REQUESTED BY BCA.
A12 (2.5")	76+80 LT	10"	20"	#5	1.75"	16"	#5	2.25"	16"	–	–	–	–	–	–	58/56	–	YES	ADDITIONAL CORING REQUESTED BY BCA.
A13 (2.5")	76+80 RT	11"	26"	–	–	–	–	–	–	#3	1.25"	18"	#3	1.5"	16"	–	58/54	YES	ADDITIONAL CORING REQUESTED BY BCA.
A14 (2.5")	79+31.92 LT	7"	36"	#5	2.0"	8"	#5	2.25"	16"	#5	2.75"	6"	#3	2.75"	18"	48/50	56/58	YES	

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PERMANENTE DIVERSION SURVEY SHEET

CORE # DIA ( )	STA IN METRIC	CORE'S LENGTH	CORE'S DIST TO SLAB	BARS SIZE												TEST HAMMER		SAMPLER COLLECTED	REMARKS
				LT. WALL						RT. WALL						LT	RT		
				VERT.	COVER	SPACING	HORZ.	COVER	SPACING	VERT.	COVER	SPACING	HORZ.	COVER	SPACING				
B1 (2.5")	3+04.80 LT	3.75"	40"	#5	1.5"	6"	#5	2"	6"	#3	3"	7"	#3	3"	7"	50/52	52/58	YES	
B2 (2.5")	6+09.60 RT	3"	50"	#5	2.25"	7"	#5	2.5"	9"	#5	2.25"	6"	#3	2.5"	9"	58/54	50/50	YES	
B3 (2.5")	9+14.40 LT	3.5"	90"	#5	3"	6"	#5	3"	12"	#7	3.25"	7"	#5	2.5"	6"	50/48	58/60	YES	
B4 (2.5")	12+19.20 RT	5"	50"	#7	5"	15"	#5	4.5"	7"	#7	4.25"	14"	#5	4.5"	14"	56/54	56/48	YES	
B5 (2.5")	15+24 LT	3"	54"	#7	3.5"	6"	#7	3.75"	6"	#7	2.25"	7"	#5	3"	6"	58/50	58/56	YES	
B6 (2.5")	18+28.80 RT	10"	40"	#7	2.5"	12"	#7	2.75"	17"	#5	2"	14"	#7	2.25"	16"	60/56	60/62	YES	
B7 (2.5")	18+90 LT	4.75"	45"	#5	2.5"	12"	#5	2.25"	12"	#5	2.25"	12"	#7	2"	12"	48/56	46/48	YES	ADDITIONAL CORING REQUESTED BY BCA.
B8 (2.5")	21+52 LT	11.25"	48"	#5	1.75"	10"	#5	2"	10"	#7	1.75"	16"	#5	1.5"	12"	52/58	58/56	YES	ADDITIONAL CORING REQUESTED BY BCA.
B9 (2.5")	21+64 RT	10.5"	54"	#5	2.5"	12"	#3	2"	10"	#5	1"	10"	#5	1.5"	10"	56/52	48/52	YES	ADDITIONAL CORING REQUESTED BY BCA.
B10 (2.5")	24+59.74 LT	7.5"	60"	#3	3.25"	10"	#3	3"	10"	#5	3"	12"	#5	2.5"	12"	52/50	52/50	YES	ADDITIONAL CORING REQUESTED BY BCA.

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HALE CREEK SURVEY SHEET

CORE # DIA ( )	STA IN METRIC	CORE'S LENGTH	CORE'S DIST TO SLAB	BARS SIZE												TEST HAMMER		SAMPLER COLLECTED	REMARKS
				LT. WALL						RT. WALL									
				VERT.	COVER	SPACING	HORZ.	COVER	SPACING	VERT.	COVER	SPACING	HORZ.	COVER	SPACING	LT	RT		
C7 (2.5”)	4+50.32 LT	10”	31”	#5	2.5”	6”	#5	2.25”	10”	#5	2.0”	12”	#3	2.0”	14”	48/44	46/44	NO	
C8 (2.5”)	1+45.52 RT	5”	30”	#7	2.0”	6”	#5	2.0”	16”	#5	1.75”	8”	#5	1.75”	16”	48/48	52/48	NO	
C1 (2.5”)	7+55.12 RT	6.5”	20”	#7	1.75”	6”	#5	1.5”	8”	#7	2.5”	17”	#7	2.5”	17”	32/52	46/55	YES	
C2 (2.5”)	10+59.92 LT	3”	35”	#5	1.75”	7”	#7	2.25”	10”	#7	2”	7”	#5	2”	16”	46/46	50/54	YES	
C3 (2.5”)	13+64.72 RT	3.5”	34”	#5	2.0”	12”	#5	2.0”	16”	#3	1”	6”	#5	1.5”	16”	51/49	46/49	YES	
C4 (2.5”)	16+69.52 LT	12”	26”	#5	1.5”	20”	#5	2.0”	18”	#5	1”	20”	#5	1.5”	18”	59/57	58/60	YES	
C5 (2.5”)	17+00 RT	13.25”	24”	#5	1.25”	20”	#3	1.25”	16”	–	–	–	–	–	–	–	57/59	NO	ADDITIONAL CORING REQUESTED BY BCA.
C6 (2.5”)	17+00 LT	11”	24”	–	–	–	–	–	–	#5	1.5	18”	#5	2.25”	18”	54/57	–	YES	ADDITIONAL CORING REQUESTED BY BCA.

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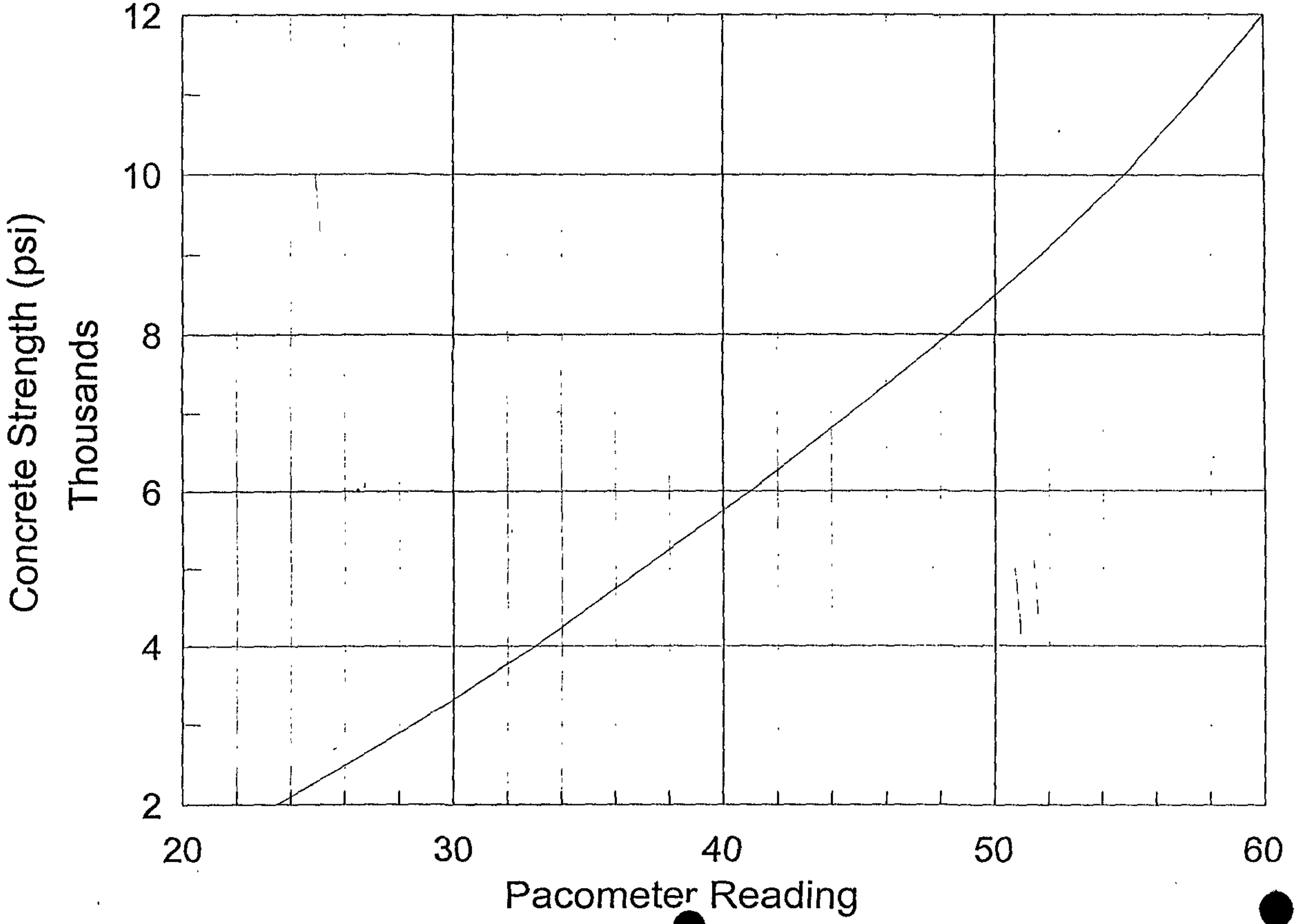
12
10
8
6
4
2
Concrete Strength (psi)
Thousands
20
30
40
50
60
Pacometer Reading